

A TEXT-BOOK
OF X-RAY DIAGNOSIS
BY BRITISH AUTHORS

"What shadows we are, and what shadows we pursue."

EDMUND BURKE, Sept 9th, 1780

A TEXT-BOOK
OF
X-RAY DIAGNOSIS
BY BRITISH AUTHORS
IN THREE VOLUMES

Edited by

S. COCHRANE SHANKS, M.D., F.R.C.P., F.F.R.
Honorary Director, X-Ray Diagnostic Department, University College Hospital

PETER KERLEY, M.D., F.R.C.P., D.M.R.E.
Physician to the X-Ray Department, Westminster Hospital,
Radiologist, Royal Chest Hospital, etc.

AND

E. W. TWINING, M.R.C.S., M.R.C.P., D.M.R.E.
Radiologist, Royal Infirmary, Manchester, Radiologist, Christie Hospital
Late Hunterian Professor, Royal College of Surgeons
Lecturer in Radiology, University of Manchester, etc.

VOLUME II

With 307 illustrations



LONDON
H. K. LEWIS & Co. LTD
1938

*First Edition
Reprinted
Reprinted*

*March 1938
January 1943
February 1944*



*The Typography and Binding
of this book conform to the
authorized economy standard*

PUBLISHERS' NOTE

The size of the volumes in this reprint has been reduced in order to comply with the regulations now in force prescribing the area of the type surface in relation to the size of the page.

The type area is the same as in the first issue and the reduction in size has taken place at the expense of the margin.

The Publishers regret this reduction, one which somewhat mars the appearance of the volumes and they hope that it will be accepted as a war time necessity. When a new edition of the work is called for it will be their endeavour to return to the original format.

LIST OF CONTRIBUTORS

- S L BAKER, Ph D, M Sc, MRCS, LRCP, DPH,
Procter Professor of Pathology and Pathological Anatomy,
University of Manchester.
- HUGH CAIRNS, MA, MB, BS, FRCS,
Nuffield Professor of Surgery, University of Oxford, Surgeon,
Neuro-Surgical Department, London Hospital, late Surgeon,
National Hospital, Queen Square, late Surgeon, Hospital for
Paralysis and Epilepsy, Maida Vale, late Hunterian Professor,
Royal College of Surgeons
- F CAMPBELL GOLDING, MB, Ch M, MRCP, DMRE,
Assistant Radiologist, Middlesex Hospital and British Red Cross
Clinic for Rheumatism, Honorary Radiologist, Royal National
Orthopaedic Hospital
- E DUFF GRAV, MA, MD, FFR, DMRE,
Honorary Radiologist, Ancoats Hospital, Manchester, Visiting
Radiologist, Park Hospital, Davyhulme
- H K GRAHAM HODGSON, CVO MB, BS, FRCP, FFR, DMRE,
Honorary Physician in charge Department of X-ray Diagnosis,
Middlesex Hospital Honorary Radiologist, Central London
Throat, Nose and Ear Hospital
- DONALD HUNTER, MD, FRCP,
Physician, with charge of Out patients, London Hospital
- M H JUPE, BA, MRCS, LRCP, FFR, DMRE,
Radiologist, London Hospital
- PETER KERLEY, MD, FRCP, FFR, DMRE,
Physician to the X-ray Department, Westminster Hospital,
Radiologist, Royal Chest Hospital
- C JENNINGS MARSHALL, MD, MS, FRCS,
Surgeon, Charing Cross Hospital, Surgeon, Victoria Hospital
for Children, Examiner in Surgery, Universities of London
and Manchester
- RUSSELL J REYNOLDS, CBE, MB, BS, FRCP, FFR, DMRE,
Physician in charge Departments of Radiology and Electro-
therapy, Charing Cross Hospital, Honorary Radiologist,
National Hospital, Queen Square, late Hunterian Professor,
Royal College of Surgeons

LIST OF CONTRIBUTORS

R E ROBERTS BSc MD DPH FFR, DMRE

Honorary Radiologist, Liverpool Royal Infirmary Victoria Central Hospital Liverpool Maternity Hospital and Liverpool Radium Institute Consulting Radiologist Liverpool Heart Hospital Lecturer in Radiology and in Applied Anatomy (Radiological) University of Liverpool

S COCHRANE SHANKS MD FRCP FFR,

Honorary Director X-ray Diagnostic Department, University College Hospital

CECIL G TEALI MB ChB FFR

Honorary Radiologist General Hospital and Children's Hospital Birmingham

J FANE TIERNEY MRCS LRCP DMRE

Assistant Radiologist Charing Cross Hospital

I W TWISNIEV MRCS MRCP FFR DMRE

Radiologist Royal Infirmary Manchester Radiologist Christie Hospital Late Hunterian Professor Royal College of Surgeons Lecturer in Radiology University of Manchester

F RONAN WILLIAMS MD FRCP FFR DMRE

Assistant Director Radiological Department St Mary's Hospital Honorary Radiologist, Willesden General Hospital

J ST GEORGE WILSON MC MB ChM FRCS LRCP FRCOG

Obstetric and Gynaecological Surgeon Liverpool Royal Infirmary Consulting Obstetrician Walton Hospital Liverpool

H M WORTH MRCS LRCP LDS IFR DMRE

Assistant Radiologist Guy's Hospital Radiologist Guy's Hospital Dental School

PREFACE

THE object of the Editors in presenting this text book is to provide within reasonable limits a comprehensive survey of the present position of X ray diagnosis. Diagnostic radiology is becoming an increasingly complex specialty, and it is difficult for one person to be equally expert in all its branches. The Editors are fortunate therefore in having the help of collaborators, both radiological and clinical, who are distinguished in particular branches of the subject. It is hoped that this has made the work the more authoritative and that it will be of value not only to the post graduate student of radiology but also to the clinician. In conformity with this design only essential details of technique are included, and the subject of X ray physics is not dealt with.

For convenience of reference, the work is published in three volumes, each containing as far as possible subjects of allied interest. Thus Vol I deals mainly with the thorax, Vol II with the abdomen, and Vol III with the skeletal and nervous systems.

It is not possible, even within the generous limits allowed by the publishers, to illustrate every condition demonstrable by radiology, but the illustrations chosen are, it is hoped, representative, and give due emphasis to the common lesions met with in radiological practice. Considerable interchange of material for illustrations has taken place between the various contributors to the book, and the Editors are greatly indebted for the loan of illustrations from other colleagues, detailed acknowledgments of which will be found at the beginning of each volume. They are also grateful to Mr Boutall, of Messrs Vaus & Crampton, for the care and attention he has given to the preparation of the blocks, and to Messrs Hazell Watson & Viney for their careful work with the printing.

Finally, the Editors desire to express their sincere thanks to the publishers, and in particular Mr H L Jackson and Mr F Boothby, for their co-operation and advice, without which this book could not have come into being.

February 1938

SUMMARY OF CONTENTS

VOL I

- CARDIOVASCULAR SYSTEM PETER KERLEY, MD,
FRCP, FFR, DMRE
RESPIRATORY SYSTEM E W TWING MRCS,
MRCP FFR, DMRE
URINARY AND MALE GENITAL TRACTS C JENNINGS
MARSHALL MD MS FRCS, and S COCHRANE SHANKS,
MD FRCP FFR

VOL II

- ALIMENTARY TRACT S COCHRANE SHANKS
BILIARY TRACT PETER KERLEY
ABDOMEN S COCHRANE SHANKS
FEMALE GENITAL TRACT R E ROBERTS BSc MD
DPhil FFR, DMRE and J ST GEORGE WILSON
MC MB, ChM, FRCS, FRCOG
OBSTETRICS R E ROBERTS

VOL III

- CENTRAL NERVOUS SYSTEM HUGH CAIRNS MA MB
BS FRCS and M H JUPE BA MRCS LRCP
FFR DMRE
ACCESSORY NASAL SINUSES LABYRINTH AND
MASIOID PROCESSES H K GRAHAM HODGSON
CJO MB BS, FRCP FFR DMRE
TEETH AND JAWS H M WORTH, MRCS LRCP
LDS FFR, DMRE
BONES AND JOINTS AND SOFT TISSUES S L BAKER,
PhD MSc MRCS, LRCP DPH T CAMPBELL
GOLDING, MB ChM, MRCP DMRE, E DUFF
GRAY, MA MD FFR, DMRE, H K GRAHAM
HODGSON DONALD HUNTER, MD FRCP, M H
JUPE, PETER KERLEY, R E ROBERTS, S COCHRANE
SHANKS, CLCIL G TEALL, MB, ChB FFR, T FANE
TIERNEY, MRCS, LRCP, DMRE, E W TWING,
E ROHAN WILLIAMS MD, FRCP, FFR, DMRE
CINERADIOGRAPHY RUSSELL J REYNOLDS, CBE MB,
BS FRCP FFR, DMRE

CONTENTS OF VOLUME TWO

	PAGE
LIST OF CONTRIBUTORS	• V-VI
PREFACE	• VII
SUMMARY OF CONTENTS	• IX

PART ONE ALIMENTARY TRACT

SECTION I

SALIVARY GLANDS PHARYNX AND OESOPHAGUS

CHAPTER		PAGE
I	THE SALIVARY GLANDS	1
II	THE NORMAL PHARYNX AND OESOPHAGUS	8
III	DISEASES OF THE PHARYNX AND OESOPHAGUS	14

SECTION II

STOMACH DUODENUM AND DIAPHRAGM

IV	GENERAL TECHNIQUE	34
V	THE NORMAL STOMACH	39
VI	GASTRIC ULCER	57
VII	OTHER INFLAMMATORY LESIONS OF THE STOMACH	80
VIII	NEOPLASMS OF THE STOMACH	86
IX	MISCELLANEOUS GASTRIC CONDITIONS	102
X	THE NORMAL DUODENUM	114
XI	DUODENAL ULCER AND OTHER INFLAMMATORY LESIONS	124
XII	MISCELLANEOUS DUODENAL LESIONS	138
XIII	THE STOMACH AND DUODENUM AFTER OPERATION	151
XIV	THE DIAPHRAGM	170

SECTION III

SMALL INTESTINE APPENDIX AND LAROE INTESTINE

XV	THE SMALL INTESTINE TECHNIQUE ANATOMY, AND PHYSIOLOGY	197
XVI	DISEASES OF THE SMALL INTESTINE	202

CONTENTS

CHAPTER		PAGE
XVII	THE APPENDIX	213
XVIII	EXAMINATION OF THE COLON	223
XIX	ANATOMY AND PHYSIOLOGY OF THE COLON	230
XX	ANATOMICAL VARIATIONS OF THE COLON	241
XXI	INFLAMMATORY DISEASES OF THE COLON	250
XXII	COLONIC STASIS AND OBSTRUCTION	267
XXIII	FUMOURS OF THE COLON	277
XXIV	DIVERTICULITIS OF THE COLON	285
XXV	THE RECTUM AND ANUS	297

PART TWO
BILIARY TRACT

XVI	ANATOMY AND PHYSIOLOGY	304
XVII	TECHNIQUE FOR X-RAY EXAMINATION OF THE BILIARY TRACT	315
XVIII	THE PATHOLOGICAL BILIARY TRACT	320

PART THREE
THE ABDOMEN

XIX	THE LIVER, Spleen, PANCREAS AND ADRENALS	343
-----	--	-----

PART FOUR
FEMALE GENITAL TRACT

XXX	X-RAYS IN GYNECOLOGY	367
-----	----------------------	-----

PART FIVE
OBSTETRICS

XXXI	GENERAL TECHNIQUE	383
XXXII	DIAGNOSIS OF PREGNANCY AND MATERNAL PELVIC DI MENSIONS	386
XXXIII	RADIOLOGICAL PELVIMETRY	392
XXXIV	CEPHALOMETRY	401
XXXV	THE RADIOLOGICAL ESTIMATION OF FETAL MATURITY	406
XXXVI	THE FETUS: POSITION, PRESENTATION AND ABNORMALITIES	412
XXXVII	PLACENTA PREVIA	430

VOLUME II

PART ONE

ALIMENTARY TRACT

BY

S. COCHRANE SHANKS, M.D., F.R.C.P., F.F.R.

A TEXT-BOOK OF X-RAY DIAGNOSIS

PART ONE

SECTION I

SALIVARY GLANDS, PHARYNX, AND OESOPHAGUS

CHAPTER I

THE SALIVARY GLANDS

ANATOMY

The Parotid Gland lies in the side of the face immediately below and in front of the ear. Its relations are as follows. Above, it is bounded by the zygoma, behind it lies the sterno mastoid muscle, in front is the ascending ramus of the mandible. It extends below to a line drawn between the tip of the mastoid process to the angle of the jaw. It sends a deep extension downwards to the pharyngeal wall, but most of the gland is superficial.

The duct of the parotid, Stenson's duct, is about $2\frac{1}{2}$ inches in length. It begins by the fusion of numerous branches in the anterior portion of the gland, and runs forward on the masseter muscle. At the anterior border of that muscle it bends sharply inwards, pierces the buccinator muscle, and runs forward under the buccal mucosa to open in the mouth opposite the second molar of the upper jaw. According to *Hamilton Bailey*, Stenson's duct is devoid of musculature. A small lobe, the *socia parotidis*, extends forwards along the posterior part of the duct.

The Submaxillary Gland lies in the submaxillary triangle in the neck. From a radiographic point of view its important relationship is that to the mandible. The upper half of the gland lies under the mandible, against the submaxillary fossa on the inner surface of that bone. This point is of importance when looking for a submaxillary calculus in a lateral radiogram. The submaxillary duct, Wharton's duct, begins by the fusion of several small ducts at the upper border of the gland. It is about 2 inches in length, and runs forwards, inwards and upwards to open in the floor of the mouth, in a papilla on the plica sublingualis close to the frenum lingue. Wharton's duct is also

devoid of muscular tissue. Its wall is much thinner than that of Stenson's duct.

The Sublingual Gland is small and almond shaped. It lies under the mucosa of the floor of the mouth. Its anterior relationship is the inner surface of the mandible close to the symphysis. Its excretory ducts, the ducts of Rivinus, are from eight to twenty in number. The majority of them open on the crest of the plica sublingualis. One or two join Wharton's duct. This last fact is of importance in sialography of the submaxillary gland. The cannula may pass into one of these ducts and the injection fail to reach the intended gland.

RADIOGRAPHIC TECHNIQUE

The salivary glands may be examined in a plain radiogram or after the injection of a contrast medium. The usefulness of the former method is limited to the demonstration of salivary calculi. For the demonstration of any other lesion of the salivary apparatus contrast medium radiography—sialography—is required.

The plain radiograms necessary depend on the site of the calculus. If it be in the parotid stereoscopic lateral radiograms should be taken centring over the gland with the neck somewhat extended and the mouth half open.

For the demonstration of submaxillary calculi stereoscopic lateral radiograms should be taken and also a submental view with an intra-oral cassette, or an occlusal dental film.

The stereoscopic lateral views should be taken with the mouth closed and the head extended. The central ray should be directed towards the suspected gland with a slight cephalic inclination just enough to avoid superimposition of the two horizontal rami of the mandible. For the intra-oral view the so called occlusal dental film of size 2½ by 3 inches should be used either plain or in an intra-oral intensifying screen cassette. The cassette or film is introduced as far into the mouth as possible the teeth gently closed on it and the central ray directed underneath the chin as nearly normal to the plane of the cassette as possible.

The technique for the submaxillary gland also serves for the sublingual. In the case of the sublingual the intra-oral film is of particular importance.

SIALOGRAPHY

Sialography may be defined as the radiographic demonstration of the salivary ducts and alveoli by means of the injection of a radiographic contrast medium.

Historical—*Larson* was the first to publish a case using potassium iodide. Several cases were then reported with lipiodol as the contrast medium, and in 1931 *R. T. Payne* gave a full account of the technique and indications and described four cases. In 1933 *Pyrah* described the sialographic picture in four cases of chronic parotitis.

Indications—Sialography is of value in the investigation of abnormalities in the ducts, salivary calculi, fistula, salitis, and tumours of the parotid and

submaxillary glands. It cannot be applied to the sublingual, for want of a large enough duct.

Technique.—Provided all manipulations are gentle, sialography is a safe procedure. So far no untoward after effects have been noted, and there is reason to believe that the introduction of Lipiodol into the glands in cases of chronic sialitis has a therapeutic effect.

Apparatus—The essential piece of apparatus is the glass cannula. This is easily made from 3 mm. glass tubing. One end of this is drawn out to a fine point 1 mm. or less in diameter. The end should be flamed to round it off, if the flaming process be overdone, the lumen is apt to be sealed off. This may be prevented by blowing through the tube during the heating process. A series of varying sizes should be at hand. The glass cannula is connected to an ordinary 5 c.c. record syringe by a flexible rubber connection. The rubber connector piece of a ureteric catheter is usually efficient, but the force needed to join the cannula and the record syringe into the connector piece may disturb the cannula in the duct and it is better to use a rubber tube attached to a bayonet catch syringe nozzle. The cannula and tube must be filled with Lipiodol before insertion, to prevent air being driven into the duct.

Payne recommends the use of an angled glass fountain pen filler, the point drawn out into a suitable cannula. This works very satisfactorily except in cases which require rather more pressure than can be exerted by the rubber bulb of the filler.

As an alternative to a glass cannula an olive tipped silver cannula may be used. This is made with a standard needle butt for direct attachment to a syringe. It is essential that the olivary tip be properly rounded for fear of damaging the delicate duct with a sharp or rough point. This can easily be verified under a microscope.

Preparation of the Patient—A mild antiseptic mouth wash should be used immediately before the injection. In order to bring the duct orifice into clear view, the gland should be massaged. Failing this, the patient should suck a slice of lemon.

The Injection—This may be given either with the patient sitting up or lying down on the X-ray couch. Sitting up is the more convenient. The cannula, filled with Lipiodol, should be introduced for about $\frac{1}{2}$ inch down the duct, and the injection of $\frac{1}{2}$ to $\frac{1}{3}$ c.c. slowly given. It may take a minute to fill the gland satisfactorily. Pain in the gland is an index that enough has been given. After the injection has been completed, the patient may keep the cannula in situ in the duct by closing the lips gently. This procedure marks the site of the orifice, and enables a further injection to be made if the first has not filled the ducts and alveoli completely.

The Radiograms—Lateral stereoscopic radiograms should be taken in the positions described under plain radiography. Stereoscopy gives so much

clearer an idea of the disposition of the ducts and alveoli that a single radiogram should not be considered an adequate investigation.

In cases where the interpretation of the sialogram is doubtful a control investigation of the sound side may be of help. The radiograms should be taken as expeditiously as possible. The Iodiprodol tends to percolate into the alveoli after ten to twenty minutes and to blur any radiograms taken after too long an interval. The hazy shadows of the minute alveoli obscure the cutlines of the fine ducts.

SALIVARY CALCULI

The presence of a calculus is the only abnormality which can be demonstrated by plain radiography and a confident opinion negative or positive



FIG. 1



FIG. 2

Two cases of submaxillary duct calculus shown by an intra-oral film

can be given radiologically because of the density of the calculi. They are composed of calcium carbonate and calcium phosphate often in alternate layers and cast a relatively dense shadow. All but the very smallest should be detectable in a satisfactory radiogram.

The submaxillary gland is much the commonest site of calculi. According to Wakeley the relative frequency in the three glands is as follows:

Submaxillary 63 per cent
Parotid 21 per cent
Sublingual 16 per cent

Calculi may occur either in the duct or in the gland. The duct calculi are oval or elongated rather rough in surface lie with the long axis in that of the duct and may show lamination (Figs 1 and 2). They may attain the size of a date stone and more than one may be present.

The gland calculi tend to be round in contour may be single or multiple and may reach the size of a green pea (Fig. 3).

Although the above characteristics and the position of the calculus relative to the bony landmarks may be some indication of its site, sialography gives accurate information, and in addition will indicate the degree of the essential aetiological factor, the associated sialitis. This additional method should therefore be used in all cases of salivary calculus.

Differential Diagnosis.—Two structures may be mistaken for a salivary calculus: a calcified gland, and a localised area of bone sclerosis in the mandible. The latter especially may simulate a calculus in a plain lateral view, but stereoscopy and the occlusal film show its true nature.

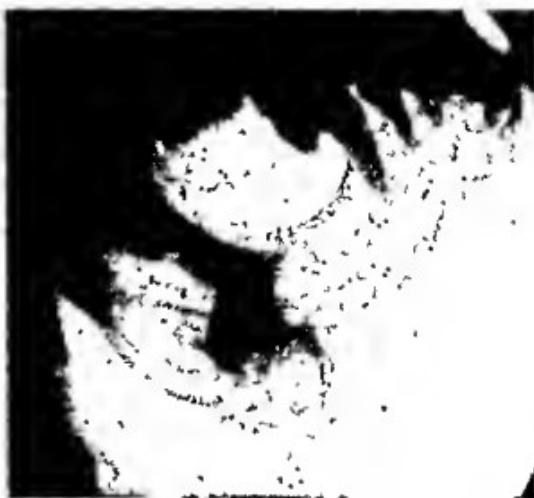


FIG. 3.—Large submaxillary calculus.



FIG. 4.—Normal parotid sialogram. Note the double saccular parotid—an anatomical variation.

THE NORMAL SIALOGRAM

In the parotid sialogram the duct is narrowest at the buccal orifice and rapidly widens out to a calibre of about a millimetre. The bend which it takes as it dips through the buccinator muscle is usually visible. On tracing the duct back to the gland a large branch duct forks upward—the duct of the *soritis parotidis*. The ducts of the main gland are many and tend to join the main duct at right angles giving an appearance like a double comb. These sub-lobular ducts break up into fine twigs. No terminal gemmules or dilatations are visible. In the submaxillary sialogram the duct lumen may be larger in bore—up to 2 mm—as a result of its thin distensible wall.



FIG. 5.—Chronic salitis of the parotid gland. Sialogram showing terminal dilatations of the ducts or "sialectia".



FIG. 6.—Sialogram of a mixed tumour of the parotid. Note the filling defect of the upper part of the gland.

The secondary ductules are less regular than in the parotid but otherwise present a similar appearance (Fig. 4).

Salivary Fistulae—*The internal fistulae* are of no importance since they cause the patient no inconvenience.

Of the external fistulae the gland fistula usually heals rapidly under simple treatment and the only one of radiographic interest is the fistula of Stenson's duct.

It is desirable to demonstrate with what part of the duct the fistula communicates since the nearer to the gland it is the more difficult the treatment.

The fistulous opening on the cheek should be marked with a fine wire ring and the duct injected with lipiodol through the anatomical ostium. If the duct distal to the fistula be stenosed, it may be necessary to make the injection through the sinus. An attempt should be made in each case to fill the whole duct up to the gland.

Chronic Sialitis — It is in this class of case that sialography finds its greatest sphere of usefulness. The radiographic appearances afford evidence not only to diagnosis, but also the degree of the inflammatory process and consequently the prognosis. Changes may be evident both in the duct and in the gland.

The duct changes consist in dilatation, with, possibly, localised constrictions. The thin-walled Wharton's duct is more prone to dilatation than Stenson's. The gland changes consist in progressively increasing dilatation of the duct terminations. Commencing in an early case as minute buds the size of a pin-head or less, they gradually enlarge to a size of 1-3 mm. in diameter in long-standing cases. To this change the term sialectasis has been applied. The condition shows a close radiographic similarity to bronchiectasis (Fig. 5).

Of the two changes, the terminal dilatation—sialectasis—is the earlier, and the essential. The duct dilatation occurs less frequently. The cause of the sialectasis is not proved, but a plausible explanation is chronic back pressure from plugging of the duct with tenacious mucus or muco pus. Indeed, the sticky nature of the resting duct contents may be seen clearly in performing a sialography. On giving lemon to suck, instead of a rapid and free discharge of watery saliva, there may be seen a delayed, sluggish pouring of the orifice by the extrusion of a bead of thick mucus.

Salivary Gland Tumours — Although the nature of these tumours—i.e. their salivary gland origin—is usually evident clinically, if there be any doubt, a sialogram may be of help. The parotid gland tumours lend themselves best to this form of investigation. A filling defect is produced by the tumour. A slow-growing benign tumour tends to push the ductules on one side, and a deformity of this type may be evident. A rapidly growing invasive neoplasm destroys the ductules in its path, and in this case the sialogram shows an absence of filling of these ducts (Fig. 6).

Mikulicz's Disease — According to Payne, the radiographic appearances are normal in this condition.

CHAPTER II

THE NORMAL PHARYNX AND OESOPHAGUS

ANATOMY

As the pharynx is open to direct inspection X-ray examination is rarely called for except in cases of pharyngeal diverticulum and post cricoid carcinoma.

In a lateral view all three portions of the pharynx are visible by virtue of the air contained therein. This air space is continuous in the naso pharynx with the nasal cavities. In the oro pharynx it is bounded in front by the tongue if the mouth be closed. In the laryngo pharynx it turns forwards and narrows into the laryngeal vestibule and can be traced down into the trachea. The lower part of the laryngo pharynx below the laryngeal opening is a potential space only in the resting subject. The posterior boundary of the pharyngeal air space follows the curve of the cervical spine and any prevertebral swelling such as a retropharyngeal abscess is clearly visible. Anterior to the pharynx are two landmarks—the larynx bone and below it the thyroid cartilages usually calcified in adults and so visible. Frequently the epiglottic shadow is visible separated from the base of the tongue by the vallecula.

The oesophagus a muscular tube is about 9 to 10 inches in length. It begins at the upper border of the cricoid cartilage at the level of the 6th cervical vertebra and descends in front of the vertebral column passes through the oesophageal opening of the diaphragm to end at the cardiac orifice of the stomach opposite the eleventh dorsal vertebra. Its general direction is vertical and median but it curves slightly to the left at the root of the neck becomes median at the level of the fifth dorsal vertebra and again deviates to the left as it reaches the diaphragm. It also presents antero posterior curves corresponding to those of the cervico dorsal spine.

Certain of its relationships are of radiographic importance. In the thorax it passes behind the aortic arch separated from it by the trachea then descends in the posterior mediastinum at first to the right of the descending aorta then in front and slightly to the left of it. In front the left bronchus crosses it and below this it is in relationship to the left auricle.

In the abdomen it runs in the oesophageal groove on the posterior surface of the liver. This portion is short 1 to 1 inch in length.

The lumen varies slightly. It is narrowest at its two sphincters the cricoid and cardiac and is slightly narrower opposite the aortic arch. It presents a slight bulb or dilatation immediately above the diaphragm.

TECHNIQUE OF INVESTIGATION

The essentials of the X ray examination of the oesophagus are to observe the passage of an opaque medium along its lumen under the fluoroscopic screen, and to take radiograms thereof as a permanent record.

For routine examinations the patient should if possible be examined first in the erect position. The chest should first be screened to exclude gross abnormality, and the patient then turned into the first (right) oblique position. This brings the whole of the oesophagus into clear view as it descends in the posterior mediastinal space. On a bolus of opaque cream being swallowed, its course is observed from the mouth to the cardiac orifice. If a suspected lesion be not demonstrated by a barium cream, a barium paste or biscuit may show it.

Following the screen examination, at least two radiograms of the whole extent of the oesophagus should be taken, each immediately after swallowing a mouthful of the cream. Frequently more are necessary to determine the constancy of an abnormality. The exposures should be as brief as possible, in order to avoid transmuted cardiac movement.

In cases of gross obstruction further radiograms at intervals may be advisable, and at times the left oblique view may be of value.

Although the above procedure will show the majority of oesophageal lesions satisfactorily, it is often necessary to examine the patient in the horizontal position, or the Trendelenburg, in order to demonstrate the upper and lower limits of the lesion. Again postero anterior, lateral and/or left oblique views are at times necessary to demonstrate the exact site of a pharyngeal pouch. A postero anterior view similarly demonstrates the lower end of the oesophagus in gross oesophagectasia from cardiospasm.

The Double Swallow Method—This is of use in showing the upper and lower limits of an oesophageal lesion especially carcinoma. The patient swallows some ounces of a thin barium cream. After this has passed into the stomach he assumes the right oblique Trendelenburg position. If the patient in this position swallows another mouthful, the cardia relaxes and allows regurgitation into the oesophagus. A bolus of thick cream is then swallowed, to outline the upper limit of the lesion. The method is not always successful as regurgitation may not take place but even if there is no reflux the normal transit is slower, and more likely to outline the lower limit of a stenosis. In cases of carcinoma in which it is proposed to insert a *Soufflar's* or other tube it is of particular value, and should be tried if simpler measures have failed to demonstrate the full extent of the narrowing.

The Opaque Media—The particular formula used for the barium cream is unimportant, provided it contains a sufficiency of barium and is of the proper consistency, that of a thick uniform cream. If the oesophagus only requires investigation any excipient may be used cereal, Benger's, mucilage. If, however, as is frequently the case, the stomach also is to be studied, the cream

should be suitable also for that organ and it is the writer's custom to use a cream the same as for the stomach. This can be made thicker if found on preliminary examination to be necessary, by the addition of barium sulphate powder.

The formula used by the writer is as follows:

Barium Sulphate	ʒ 10
Saccharine	grs 2
Gum Tragacanth	grs 60
Jelly of Raspberry	ʒ 4½
Aq s.t	ʒ 1

A satisfactory paste is formed by mixing equal parts of the above and powdered barium sulphate.

Barium Biscuit—Several satisfactory brands are on the market. These are of use when it is desired to excite an intermittent spasm of the oesophagus. The biscuit should be swallowed with as little mastication as possible but it should be borne in mind that if swallowed too dry it may stick in a normal oesophagus for quite an appreciable time.

The barium pellet usually in the form of a barium glycerine suppository is still more erratic in its behaviour. It may remain immobile in the normal oesophagus for many seconds or even minutes and in a case of obstruction may be arrested some distance above the site of the lesion. In such a case a mouthful of water will cause its descent to the actual site of obstruction.

Barium Wool—This consists of small pledgets of wool soaked in barium cream and is of value in showing the site of an impacted fishbone or other transparent pointed foreign body in the oesophagus.

Barium cream followed by water may be of value in certain cases of impacted foreign body (q.v.).

An important point in technique is that if obstruction be present a thin cream should always be used first. The use in the first instance of a paste or biscuit is liable to cause the patient some distress if the stenosis be marked.

THE PHYSIOLOGY OF SWALLOWING

A. F. Barclay has made an admirable and very complete X-ray study of the process of deglutition and the description below is based on the very full account he has recently published of his research.

He studied fluoroscopically and by serial radiograms the act of deglutition in a large number of normal subjects.

Briefly the sequence of events as he describes them is as follows:

- (1) THE PHARYNGEAL SPACES
- (2) THE PHARYNOEAL SPACE becomes obliterated for a fraction of a second immediately before the food is propelled backwards over the tongue.
- (3) THE PHARYNOEAL SPACE then opens to receive the bolus which is rapidly shot into it and down into the upper third of the oesophagus. The

food is seen by the fluoroscope to pass down so quickly as to suggest that it is sucked down

During the act of swallowing, all three pharyngeal openings, nasal, oral, and laryngeal, are firmly closed

(4) THE RÔLE OF THE EPIGLOTTIS is a curious one. It was formerly held that the epiglottis acted as a cover to the laryngeal vestibule. Nothing of this nature takes place and apparently the chief function of the epiglottis is to form, with the vallecula in front of it, a trap for saliva passing down the back of the tongue between the acts of deglutition.

During deglutition the epiglottis is pressed against the posterior pharyngeal wall in the closed phase. In the open phase, when the bolus is being shot back into the pharynx, the epiglottis projects upwards, free of both anterior and posterior pharyngeal walls, "like a rock projecting upwards under a waterfall" as *Barclay* puts it. Normally food passes over it into the pharynx, but occasionally a small portion is trapped by it and lodges in the vallecula, thence to be dislodged by a second act of swallowing.

(5) THE CLOSURE OF THE NASO PHARYNX results from the combined action of the superior constrictor of the pharynx and elevation of the palate.

(6) THE TONGUE closes the oro pharyngeal opening.

(7) THE CLOSURE OF THE LARYNGEAL ORIFICE is a complicated process. Firstly, the laryngeal vestibule is obliterated as far as the false vocal cords by a protrusion of the base of the tongue backwards and downwards between the hyoid bone in front and the epiglottidean base behind. The hyoid rises and appears to "swallow" the base of the tongue. Secondly the anterior wall of the laryngo pharynx rises behind and on either side of the laryngeal vestibule and further occludes it. The muscular action involved in this last process is obscure but the anterior pharyngeal wall below the laryngeal vestibule is very loosely attached, and this radiological observation is certainly possible anatomically.

A final paradoxical observation in *Barclay's* research is that the vestibule of the larynx appears to open up as the hyoid bone descends and just as the food is about to pass down behind it.

The above complicated act of deglutition is continued into the upper third of the oesophagus. Below that level the peristaltic action of the oesophagus takes charge. In other words, the chain of reflex action includes the upper part of the oesophagus.

The rapidity of the transit of the food in this reflex was investigated by *Barclay* in collaboration with *Anrep*, and they came to the conclusion that the food really was sucked down and that there is a negative pressure in the lower pharynx and upper oesophagus. They found, on passing a rubber catheter into the upper oesophagus and connecting it to a manometer, a negative pressure of 16-18 cm water when bread was swallowed.

In the Lower Two-thirds of the oesophagus the food is impelled downwards

by a rapid peristaltic wave. This wave is not deep and does not segment the bolus. It does not produce an occlusive peristaltic ring and if obstruction be present below some of a fluid medium is squirted up through the ring to

simulate reverse peristalsis. True reverse peristalsis does not appear to occur in the oesophagus.

The action of the cardiac sphincter is variable in the normal subject. Sometimes it appears to act as a patulous canal and at other times as a sphincter responding to the inhibitory impulse of a peristaltic wave in the oesophagus.

NORMAL X-RAY APPEARANCES

In the erect position the barium cream can be seen to pass smoothly down the oesophagus in a rapid peristaltic wave. In the right oblique view its course is down the posterior mediastinum with the dorsal spine behind and the aorta and heart in front. It follows the curve of the spine separated from it by about an inch. The aortic arch indents it slightly—the aortic impression.

In addition to the aortic impression there are described three other slighter indentations of the oesophagus caused from above downwards by the left main bronchus, the left auricle and the lower end of the thoracic aorta. These are of importance in cardio vascular disease and are considered in detail in that section (Fig. 7).

In both the first oblique and postero anterior views all four impressions are concave to the left.



FIG.—Normal oesophagus in the right antero-posterior view.

The oesophageal lumen as visualised by the opaque cream varies somewhat at different levels. The aortic impression causes an apparent narrowing. From this point the lumen becomes wider down to the diaphragm. Just above this it narrows and finally tapers towards the cardia.

The rate of transit through the oesophagus depends, in the normal subject, on the position of the patient and the consistency of the contrast medium. In the erect position, with the cream above described, the average time is two to three seconds. This time is lengthened with thicker media and with a dry biscuit which has been swallowed with little ensibvation the time may be thirty seconds or even a minute or two.

The supine posture increases the time of transit with the standard cream up to four to six seconds but not that of the thicker media.

Frequently a small residue remains in the lower oesophagus, after the swallowing of a bolus of the cream. It shows as a thin streak or series of longitudinal striae above the level of the diaphragm, which gradually disappear after a short interval. When a quantity of thin cream is swallowed quickly the lower part of the oesophagus may fill up to a considerable extent, e.g. the whole of the lower third, and then empty suddenly into the stomach.

In the postero anterior view most of the oesophagus is partly obscured by the mediastinal cardiac, and spinal shadows. This view is of use in examining the last few inches of the oesophagus, and in the investigation of diverticula and cardiospasm.

CHAPTER III

DISEASES OF THE PHARYNX AND OESOPHAGUS

DYSPHACIA

THE vast majority of cases referred for oesophageal examination are so referred on account of dysphagia and X-ray investigation affords the most accurate and the safest method of determining the presence site and type of a lesion causing that symptom. Before considering the various types of oesophageal obstruction certain general considerations are worthy of note. The X-ray appearances under the fluorescent screen vary considerably according to the stage and site of the obstruction.

Stages of Oesophageal Obstruction

FIRST STAGE of Simple Dysphagia — In this there is no pain little dilatation and little obstruction. Fluids may pass and only thicker media cause any discomfort.

SECOND STAGE that of painful dysphagia. The patient beginning to lose flesh definite delay in the oesophagus with powerful peristalsis and reflux of the medium.

THIRD STAGE the stage of atonic dilatation and starvation of the patient. The oesophagus gives up the struggle and acts as a reservoir. Barium may remain in it for hours.

Variations in the Picture according to the Site of the Obstruction

IN OBSTRUCTION IN THE UPPER THIRD the dysphagia is marked. The act of deglutition itself is difficult the barium is rapidly regurgitated the epiglottic vallecula pyriform fossae and larynx tend to be coated with barium and some of the medium frequently passes into the trachea accompanied by coughing and distress on the part of the patient. There is little or no dilatation in the oesophagus proximal to the obstruction as little of the contrast medium is retained therein.

IN THE MIDDLE THIRD there is less difficulty in deglutition less tendency to distressing regurgitation and more dilatation of the oesophagus.

IN THE LOWER THIRD the oesophageal dilatation is at its maximum, discomfort at its minimum and retention of the opaque cream above the point of obstruction is considerable.

At any given point the degree of dilatation varies according to the type of lesion. Thus it is greater in benign than in carcinomatous stenosis and

reaches its maximum in spastic conditions, cardiospasm being the extreme example. It also varies directly with the degree of narrowing.

PHARYNGEAL DYSPHAGIA

In a number of conditions in the pharynx there may be a considerable dysphagia quite apart from any obstruction in the oesophagus. Amongst the causes of this are bulbar palsy, pharyngeal pouch, extrinsic pressure on the pharynx from tumour or prevertebral abscess, hypopharyngeal or post cricoid carcinoma, acute tonsillitis or other type of "sore throat," Plummer Vinson syndrome or even simple nervousness.

The X-ray appearances on swallowing a mouthful of barium are the same as those of high oesophageal obstruction (or more exaggerated in degree), except that as soon as the barium reaches the oesophagus proper it passes down normally. In addition, some of the above causal lesions show special radiographic characteristics which render them recognisable.

Extrinsic Pressure from prevertebral abscess or tumour is visible in a true lateral picture of the neck by encroachment on the pharyngeal air space. In the former, the forward bulge of the posterior pharyngeal wall is readily recognisable.

Pharyngeal Diverticulum.—The rare congenital post tonsillar diverticula arising in connection with the second branchial cleft are not susceptible to X-ray demonstration and require no consideration.

The deep pharyngeal pressure diverticulum is a much commoner lesion and is clearly demonstrated by X-ray examination. These diverticula, still commonly referred to as oesophageal, occur on the posterior wall of the pharynx, about 1 cm. above the upper end of the oesophagus at the pharyngeal dimple. This dimple, median in site, marks a small gap between the oblique and transverse fibres of the inferior constrictor of the pharynx, and the pouch commences as a herniation of the mucosa through that gap. The commonly accepted view of the mechanism of development of the pouch is that repeated forcing of food into this pocket during the act of swallowing gradually enlarges this pouch downwards until a diverticulum of large dimensions may result. The opening of the pouch is median, transverse and slit-like and may reach an inch in length. This theory is at variance with Barclay's theory of the act of deglutition, described above, and he suggests that adhesions of the posterior pharyngeal wall to the prevertebral fascia behind may be the cause. The pouch, when empty, is collapsed in the coronal plane and as a rule lies in the midline but as it enlarges may deviate somewhat to either side, more commonly to the left.

X-RAY APPEARANCES.—In the right or left oblique position the contrast medium is seen to pass down into a rounded flask-shaped pouch, and then to spill over anteriorly down the oesophagus. Frequently the barium cream passes into both simultaneously. In early cases without marked symptoms,

in which the pouch is small it may retain a residue or may remain quite full without discomfort and empty very gradually. A pharyngeal pouch does not as a rule cause oesophageal obstruction by extrinsic pressure. Even when large the dysphagia is caused by overflow emptying of the filled pouch into the pharynx resulting in hawking and choking until it is partly emptied. A pool may be left for some time in the fundus of the sac. Characteristically the barium filled pouch shows a horizontal fluid level and a successful radio-

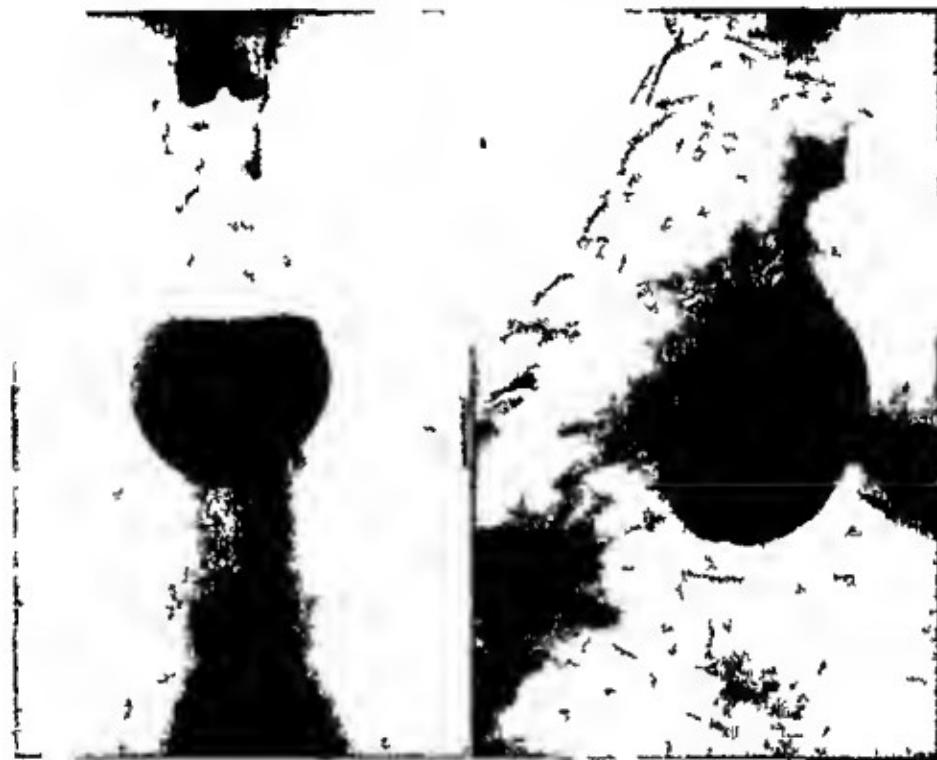


FIG. 8.—Two cases of pharyngeal pouch seen in the postero-anterior and right oblique respectively.

gram of the condition should show a stream of barium cream passing down the oesophagus in front of the shadow of the pouch (Fig. 8).

The size of the pouch may vary from 1-10 cm across and one of the latter dimensions may have a capacity of as much as 4-5 oz. The contour of the barium filled sac is regular and rounded unless food remnants are already present therein. The outline of the sac in the postero anterior view is occasionally bilocular taking the shape of an inverted conventional heart. Carenaoma may develop in a pouch and be visible as a filling defect in the barium shadow.

This view is of value in determining to which side a diverticulum deviates if at all, a point of importance in case of operation.

Traction Diverticula are very rare. They result from the traction on the oesophagus from contracting extrinsic scar tissue. According to R. S. Paterson (Fig. 9) they are usually situated on the right anterior wall of the oesophagus and are horizontally disposed. They are therefore best viewed in the left oblique position. They fill better with the patient lying down. The great majority of them are symptomless but Paterson records that dysphagia, regurgitation and substernal pain have occurred from impaction of food in the pouch. Those which are epiphrenic and epieribiac in site may be associated with dysphagia and oesophagectasia (Schin.)

Hypopharyngeal and Post cricoid Carcinoma — A true lateral position should be used in investigating this condition. The dysphagia is marked and the sequence of events so rapid as seen under the fluoroscope after an opaque swallow that little can be seen beyond that the opaque medium does not pass smoothly into the oesophagus. Regurgitation of some of the barium is common usually by a coughing reflex. This latter is induced by escape of the cream into the larynx. A radiogram taken after an



FIG. 9.—Congenital partial thoracic stomach with short oesophagus and a small tract on diverticulum of the oesophagus visible only in the left oblique s. p. n. view.

opaque bolus has been swallowed will show irregular fragments of barium entangled in the growth, and probably some coating with barium of the vallecula, pyriform fossa and even larynx and trachea.



FIG. 10.—Early post-criocid carcinoma causing slight oesophageal obstruction and pressing on the posterior wall of the trachea.

and the diagnosis must rest on the clinical and haematological features.

CONGENITAL MALFORMATIONS OF THE OESOPHAGUS

These are very rare and are usually incompatible with life. According to Whipham and Fagge the following have been recorded:

Congenital absence

Congenital atresia, with or without tracheo-oesophageal fistula

Congenital stenosis of the lower end

Bifurcation, uniting at the lower end

A lateral radio gram, taken without any opaque swallow sometimes gives quite a characteristic picture. The tumour projecting into the hypopharynx encroaches on the air space and its outline is thus shown up in relief. This applies particularly to a tumour growing from the posterior wall (Fig. 10).

Plummer-Vinson Syndrome.—Dysphagia is a common symptom in this condition, resulting from atrophy of the buccal and pharyngeal mucosa and spasm or achalasia of the crico-pharyngeal sphincter. The radiographic picture is merely that of pharyngeal dysphagia,

The symptomatology of the obstructive lesions is very typical—*inability to retain fluids, regurgitation of fluid through the nose, attacks of dyspnoea, cough and cyanosis on feeding, and broncho pneumonia, dehydration, wasting and death in a week or so.*

In cases where there is a tracheo oesophageal fistula the upper oesophagus ends below as a blind pouch and the lower oesophagus communicates above with the trachea usually at the bifurcation. Gas therefore reaches the stomach and intestine via the trachea and lower gullet. The radiographic diagnosis rests on the demonstration of a barium filled blind upper oesophageal pouch and a stomach distended with gas. Mathieu and Goldsmith have recorded two such cases.

FOREIGN BODIES IN THE OESOPHAGUS

These may be of many varieties but fall into two types—opaque and transparent. The technique for each type is different.

Whether a foreign body becomes impacted in the gullet or not depends on its size and shape. Small rounded bodies pass larger ones and most irregular or spiked ones even though small usually impact. The impaction of small irregular bodies depends on their causing trauma to the oesophageal mucosa—with resultant spasm.

Opaque Foreign Bodies—The variety of these which have been recorded is legion. Coins, small tooth plates, pins, safety pins, needles, portions of children's toys and dense meat bones are all of common occurrence (Fig. 11). The commonest site of impaction is a little above the aortic arch and next at the lower end of the oesophagus. Impacted flat bodies e.g. coins lie in the coronal planes. In the trachea they impinge in the sagittal plane—a distinguishing feature. Small pointed bodies such as pins or needles may impinge at any site. They often pass into the stomach and their impaction depends on penetration of the point into the oesophageal wall. They form the most dangerous type because of this habitability. The writer met with a case in which a Gillette razor blade became impacted and which resulted in a fatal mediastinitis.

The large opaque foreign bodies are easily detected by X-ray examination both under the screen and in a radiogram. A series of radiograms must however be made in every case in which it is suspected that an opaque foreign body has been swallowed beginning with the oesophagus. If none is found therein the whole abdomen should be examined in case the object has escaped through the cardia. It is wise also to make sure by radiograms that the body is not in the bronchial tree.

Calcification in the cricoid or arytenoid cartilages may simulate an impacted bone. A distinguishing point is that a barium swallow passes behind them but the arytenoids are so close to the pharyngeal lumen that differentiation may be impossible without pharyngoscopy.

Frequently small bodies such as pins cannot be seen on screen examination. They are always visible in radiograms of first quality.

After an opaque foreign body has been localised in the oesophagus a



(a) The bone in the gullet



(b) Barium wool pledge impaled on the bone



(c) The extracted bone 1 ½ size

FIG. 11.—Pheasant bone impacted in the m. of larynx

mouthful of opaque cream may be given to determine the degree of spasm or obstruction.

Transparent Foreign Bodies—The common ones are small or thin meat and fish bones and vulcanite fragments of tooth plates.

As the foreign body is not directly demonstrable in a radiogram its presence

impacted in the oesophagus suggested by the symptomatology, must be shown by other means.

(1) A *barium cream* may demonstrate an obstruction at the site of the impaction either from the foreign body itself if it be large or from spasm if ulceration has taken place. Frequently however the cream is seen to pass down without any obstruction when the foreign body is small such as a fish bone.

(2) In such a case a *small pledge of wool* soaked in barium cream should be swallowed by the patient and its course down the oesophagus observed fluoroscopically. It is given in the hope that it may become entangled in the projections of the foreign body and a clue be afforded to the site of the latter. This test is not very certain as in the normal subject the passage of the pledge down the oesophagus may be slow and erratic. A small chaser of opaque cream may help it down to the impacted body but frequently it misses it down past it. Some laryngologists dislike this method as it may obscure the foreign body.

(3) A method *Turpin* recommends is to give alternate drinks of *barium cream and water*. The latter clears a normal oesophagus but may not if a foreign body is impacted. The value of the test is enhanced if repetition several times always gives the same result.

CARCINOMA OF THE OESOPHAGUS

Carcinoma is far and away the commonest intrinsic lesion found in the oesophagus. It probably accounts for at least 90 per cent of all cases of dysphagia examined in an X-ray department.

Types

- (1) Squamous celled the common variety
- (2) Cylindrical celled arising from the mucosal glands
- (3) Collloid
- (4) Diffuse scirrhous.

The two latter are rare.

Morbid Anatomy — At first limited to the mucosa the growth tends to become annular in distribution and thus to cause stenosis. Small cauliflower excrescences and ulceration combine to produce a narrow tortuous channel the appearance of which is so characteristic in a radiogram. In time the growth infiltrates the muscular coats of the oesophagus and then the mediastinum. Perforation is not an uncommon sequel most commonly into the great vessels less commonly into the trachea or bronchus and rarely into the pleura or lung. Metastases are uncommon.

Sites — Although any portion may be involved the sites of election are the narrow portions of the oesophagus namely the upper and lower ends and in the region of the tracheal bifurcation. The relative frequency of occurrence at each site is still a matter of dispute but it is probably commonest at or a little



below the tracheal bifurcation and certainly occurs more frequently in the thorax than in the cervical portion.

Radiographic Features—If as is the rule some narrowing of the



FIG. 1.—Filling defect of an obstructing carcinoma of the upper third of the oesophagus.



FIG. 13.—Carcinoma of the oesophagus. Oesophagoscopy showed a tumour projecting from the right wall of the oesophagus into its lumen.

oesophageal lumen is present a carcinoma of the gullet presents characteristic features. The oesophagus above the growth is to some extent dilated this becoming more marked the tighter the stricture becomes and the lower the site of the lesion in the oesophagus. The dilated portion may

taper rather abruptly and irregularly into the stenosed passage, or may overhang it.

This irregularity is dependent on the precise contour of the upper part of the growth, and if the latter be of the "cauliflower" type, quite a large filling defect may be seen at the lower end of the dilated portion. The stenosed passage itself may be from 1 to 4 or 5 inches in length and in the longer varieties it may be necessary to examine in the horizontal position or to use

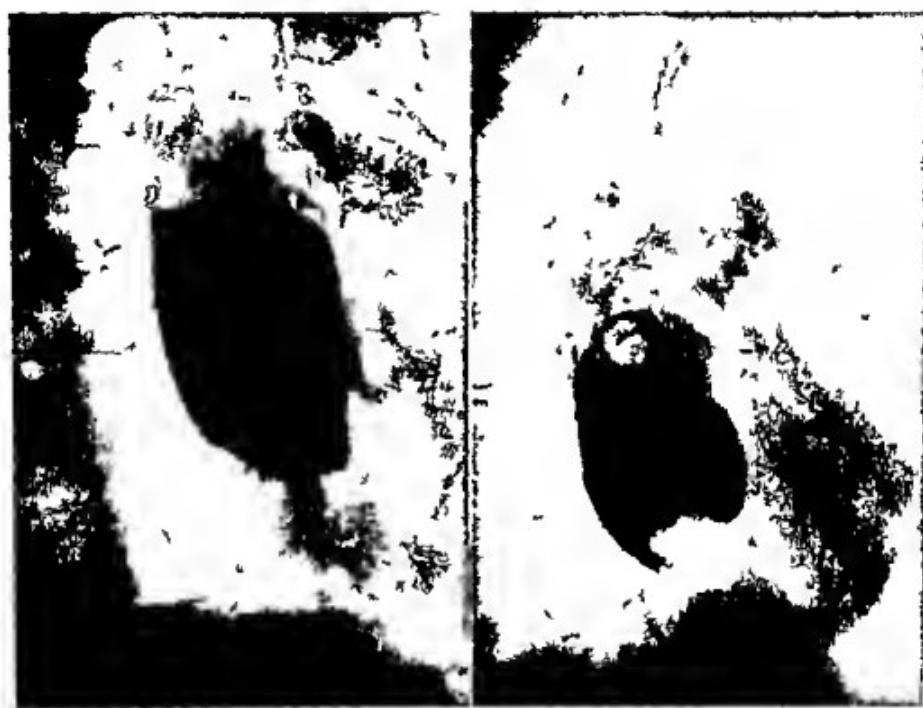


FIG. 14.—Two cases of obstructing carcinoma of the lower oesophagus.

the double swallow method in order to demonstrate its whole length. In cases where the stenosis is shorter, the routine examination in the erect position may serve to show its extent. It is of importance to show the stenosis in its entirety if radiotherapy or intubation is contemplated.

The most characteristic features of the carcinomatous stricture are its irregularity and the constancy of that irregularity. The barium filled lumen typically shows spiky projections and angulations, and the barium stream is frequently broken up into two portions by an intervening protuberant mass of growth, a filling-defect of the stricture itself (Figs. 12-14).

These irregularities are constant allowing for variations due to varying amounts of barium contained in the stricture.

This constancy is best tested by the superimposition of successive films, each taken after swallowing a bolus of barium emulsion. At least two radiograms should be taken as a routine.

In the rarer scirrhous forms of carcinoma the stenosis is less irregular, and the spiky projections are absent. Difficulty may be experienced in distinguishing between a scirrhous carcinoma and a benign stricture and in many cases it is impossible so to do from the radiographic features alone.



FIG. 15.—Carcinoma of the oesophagus perforating a bronchus.
Note barium cream in the bronchial tree.

PERFORATION OF A CARCINOMA.—The only varieties of perforation that reach the radiologist are those into the mediastinum, bronchus, or pleura. If into the mediastinum a barium-filled pocket will be seen on swallowing provided the oedema of the resulting mediastinitis does not compress the oesophagus above the perforation. In cases where the bronchus is perforated the emulsion passes into the bronchi, accompanied by coughing and distress (Fig. 15).

If the pleural cavity be involved the barium cream may flood the pleura or remain localised by pre-existing adhesions.

INTUBATION AND RADIUM THERAPY.—X-ray examination is often required after the insertion of a Souttar's or Symond's tube or the implantation of radon seeds. A radiogram taken in the right oblique view with or without a barium swallow will show if the tube is in the correct position (Fig. 16). Superimposition of the film so taken on that taken of the lesion before intubation is

frequently a help. Again such film taken after a barium swallow will show if the lower end of the tube has reached the lower limit of the stenosed passage. If the tube has ulcerated through the stenosis and passed down the oesophagus or into the alimentary canal below this will be at once apparent.

It is difficult in a plain radiogram to do more than enumerate the radon seeds implanted. Their distribution relative to the tumour cannot be arrived at although a stereoscopic pair of radiograms may give a rough idea. If a



FIG. 16.—Cases of the oesophagus before and after treatment with a Souttar's tube.

barium cream be swallowed just before such a pur are taken the stenosed lumen may also be seen stereoscopically and help in the localisation.

SIMPLE TUMOURS OF THE OESOPHAGUS

These are extremely rare. *Palugya* described the X-ray appearances in a case of pedunculated fibroma. The features he noted indicate the signs to be expected in these cases. The opaque medium is seen on screen examination to be slowed up in a part of the oesophagus which shows no stenosis but which on the contrary may actually appear widened. The barium column

may be seen to be divided by a central clear area—the tumour. This translucent area may show some marbling from the adhesion of barium to the tumour surface and this process may give an outline of the tumour in relief after the main mass of barium has passed on. In contradistinction to carcinoma the walls of the oesophagus in the affected region show no evidence of infiltration and present smooth contours.

BENIGN STRICTURE OF THE OESOPHAGUS

Aetiology—Simple fibrous stricture of the oesophagus is a late result of ulceration of the mucosa.

This ulceration is generally the result of swallowing corrosive fluids or boiling water. Occasionally it follows the impaction of a foreign body whilst rarely it is tuberculous or syphilitic.

Morbid Anatomy—The formation of the stricture depends entirely on the position extent and degree of the trauma or ulcer which is its cause.

In the case of corrosive fluids the injury tends to be localised at the three narrow portions of the oesophagus although the damage may extend over a large portion or the whole of the oesophageal lumen.

Types

ANNULLAR—This arises from a localised caustic burn or an ulcer from an imbibed foreign body. It is not common.

TUBULAR—This is the common type resulting from an extensive burn or ulceration. The muscular coats of the oesophagus are fibrosed and a dense tubular stricture of considerable length results (Fig. 17). If the original lesion involved the peri-oesophageal tissues fibrous contracture may produce displacement of the oesophagus.

In untreated cases these strictures may increase in severity until they become absolute.

Radiological Features

ANNULLAR TYPE—The proximal portion of the oesophagus is dilated. The degree of dilatation is dependent on the site of the stricture being greater the lower the latter is situated. It is commonly held to be greater than in malignant stricture. The dilated portion terminates conically below into the stricture with as a rule little irregularity and no supra stenotic filling defects.

The stricture itself shows none of the spiky irregularities of the carcinoma type variety. These strictures may be multiple.

TUBULAR TYPE—Here a considerable portion of the oesophagus may be narrowed. The degree of stenosis may vary from point to point along the extent of the stricture but as a rule it lacks the irregularity of the neoplastic type. As these strictures usually result from corrosive action the oesophagus

above the actual narrowing tends to become fibrosed from a lesser caustic action and dilatation is therefore absent. Any marked deviation of the oesophageal lumen indicates mediastinal fibrosis and constricture.

The chief diagnostic difficulty in benign stricture is to differentiate it



FIG. 17.—Two cases of benign stricture of the oesophagus. (a) History of laryngitis since childhood, no cause found ("congenital"). (b) Tubular stricture three months after swallowing tablets of salts.

radiographically from the scirrous type of carcinoma. As a rule however the matter is settled by the history of previous trauma.

Treatment.—Fluoroscopy may be of help during the passage of dilating bougies, a procedure which is often difficult.

SPASTIC OBSTRUCTION OF THE OESOPHAGUS

The following may occur

- (1) Cardiospasm
- (2) Spasm from ulceration
- (3) Spasm from impaction of foreign bodies (This has already been described)
- (4) Spasm above the cardia without obvious organic cause

Cardiospasm (*Δγυ oesophagectasia* achalasia of the cardia)

In this condition there occurs a diffuse and considerable dilatation of the oesophageal lumen associated with a constriction of the cardia. It is not a common condition but accounts for the great majority of cases of spastic obstruction.

PATHOLOGY — In a well developed case the following changes will be found:

(1) The oesophagus is markedly dilated in its lower part. The dilatation gradually diminishes upwards and is virtually non-existent in the cervical portion. In no other form of obstruction does the degree of dilatation approach to that found in this condition.

(2) The entire muscular coat becomes hypertrophied.

(3) The oesophagus becomes lengthened. If this be marked the oesophagus may assume an S-shaped contour the lower convexity to the left.

(4) In a late stage the muscular coat may atrophy the mucosa become thickened and later develop multiple ulcers.

(5) The cardiac sphincter is in a state of tight muscular contraction and the mucosa thereof thrown into longitudinal folds. There is no actual hypertrophy of the sphincter.

PROGNOSIS — The condition occurs particularly in young adults of both sexes with a preponderance in females. It may however occur at any age, and *Lagmrod* has described a case in an infant of 16 months.

There are two theories as to the mechanism of the obstruction. The older view is that it is an intrinsic spasm of the sphincter. According to *Hurst* it is due to the failure of the sphincter to relax the result of a fault in the neuro-muscular reflex. He suggests degeneration of Auerbach's plexus as the causative lesion. In favour of this view is the absence of hypertrophy of the sphincter and the degree of dilatation above in other words a reciprocal failure of sympathetic inhibition and of propulsive contraction above.

RADIOLOGICAL FEATURES — The striking feature in a marked case is the oesophagectasia. On observing the patient in the right oblique position whilst he is swallowing the opaque cream the latter is seen to slide down the dilated oesophagus and then to form a pool at or just below the diaphragm the level rising as the oesophagus becomes filled. Very frequently the oesophagus is already partly filled with transparent contents in which case the

barium will be seen to sink slowly in blobs through these contents to the foot of the oesophagus. The transparent fluid floats on top of the barium and is gradually lifted to the upper portion of the oesophagus. At the junction level of barium and retained contents there is usually some admixture of the two particularly if the latter contains imperfectly masticated food. The lower part of the dilated oesophagus is typically conical tapering smoothly to a point—the sphincter itself. The smooth regularity of the cone is a diagnostic point. If a filling defect be present in the lower end of the shadow it may be the result of a food residue. This should be excluded by re-examination before labelling as a carcinoma a case which otherwise presents the features of achalasia.

As the obstruction is low down the dilated oesophagus displays considerable tolerance to retained contents. A severe degree of oesophagectasia may contain when full 10-20 oz of fluid and tolerate without any discomfort 5-10 oz for a considerable time. In many cases there is always throughout the day a residue of some ounces carried on from one meal to the next. A residue up to twenty-four hours is not uncommon.

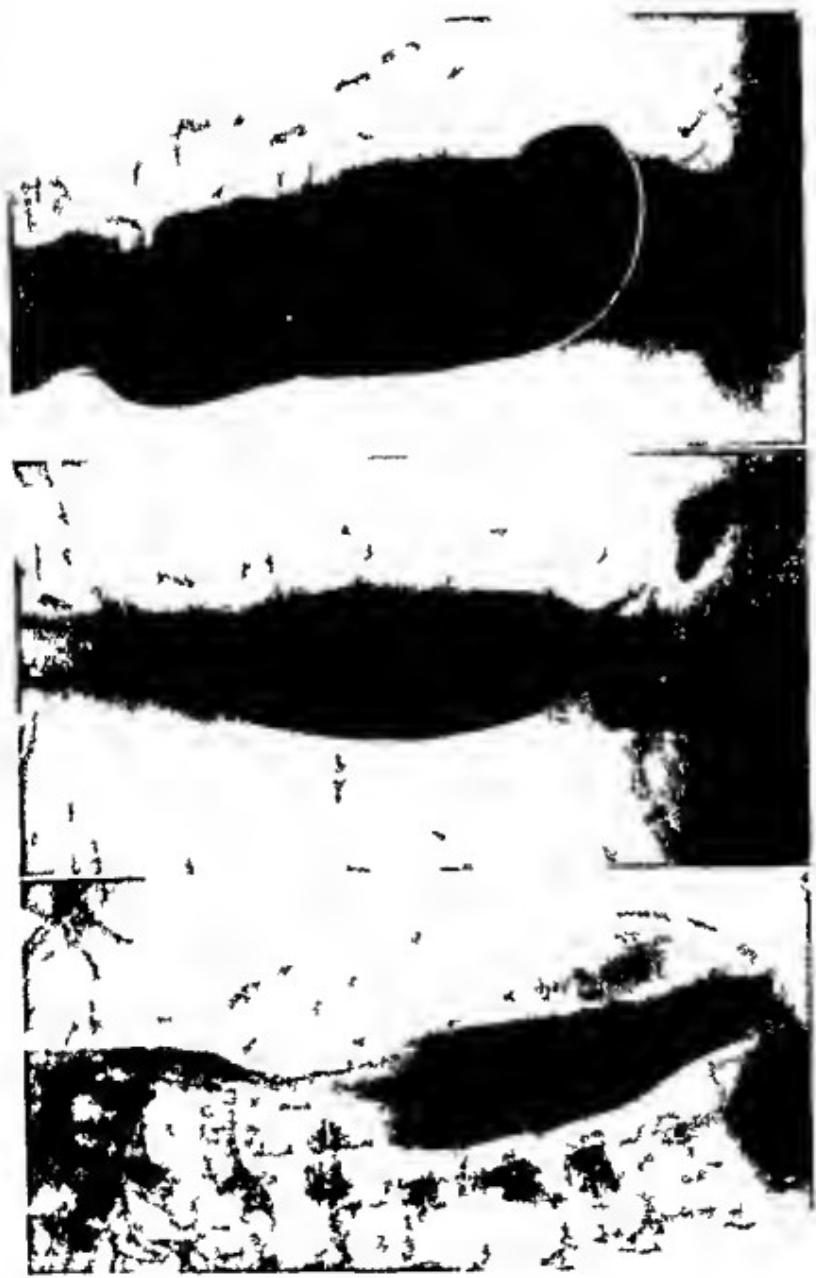
In the right oblique view the pointed termination of the barium shadow lies below the diaphragmatic domes as these are higher than the oesophageal hiatus immediately below which the oesophageal sphincter lies. Sometimes a clearer outline of this diagnostically all important termination is obtained with the patient in the postero-inferior position. In this view the barium cone points downwards and to the left and again lies below the level of the dome. In this view again the S curve of gross oesophagectasia is best demonstrated (Fig. 18).

The obstruction at the sphincter is never absolute and rarely approaches to that degree. As a rule when the oesophagus becomes full some of the cream escapes through into the stomach. It is as though above a certain level or head of barium the sphincter relaxes sufficiently to bring the barium column down again to its threshold height.

A useful fluoroscopic test of the degree of the obstruction is to ask the patient to cough. In lesser degrees of the condition this act causes a jet of the opaque cream to pass into the stomach.

RADIOPHARMIC CONTROL OF TREATMENT—In the treatment of cardio-spasm the first method to be tried is as a rule repeated dilatation of the sphincter by the mercury oesophageal bougie. This is best passed in the first instance under fluoroscopic control. The mercury-filled lower end of the bougie is of course clearly visible and if a mouthful of comparatively dilute (and so translucent) barium cream be first given to outline the position of the sphincter the tip of the bougie can be manoeuvred down against the orifice of the sphincter and its passage through into the stomach observed. The tendency for the tube to lie horizontally and push out the left oesophageal wall may be counteracted by making the patient bend to the right or left. The latter posture is more likely to be effective.

1018 Tree rings scandic soil of the red pine for left to right. The needle needles slightly tortuous



This method is successful in relieving to some extent the obstruction in cases of moderate severity. It requires weekly repetition for some months, and the degree of its success in any case is indicated by the amount of the relief of the patient's symptoms and the subsequent radiographic appearance. The latter are at first thought disappointing. Even although the symptoms are largely abated, a considerable moiety of the oesophageal dilatation remains and some food residue will be held in the oesophagus. If comparison with the radiograms taken before the treatment shows the oesophagectasia to be less and the threshold level of the residue to be lower the treatment may be regarded as satisfactorily controlling the condition.

In the case of more drastic surgical treatment, such as forcible dilatation of the sphincter from below, or cardioplasty, the radiographic *restitutio ad integrum* is more complete, as the sphincteric control has been largely destroyed.

Spasm from Ulceration

The causative ulceration may be peptic, tuberculous, or syphilitic. All are rare the two latter extremely so. A case of abscess of the oesophageal wall, following ulceration and causing obstruction, has been described.

Peptic ulceration occurs in the lower part of the oesophagus, and is presumed to result from regurgitation of acid chyme from the stomach. The symptoms are pain in the epigastrium and over the xiphisternum, precipitated by eating (especially dry foods) and heartburn. The pain may last for half an hour after food. The spasm is intermittent, and concurrent with the pain. It may be demonstrated radiologically by a barium cream after preliminary excitation of the spasm by swallowing imperfectly masticated dry biscuit or toast.

Idiopathic Spasm

The writer has seen one case of spasm of the oesophagus, about 4 inches above the cardia in which no cause was detected either radiographically or by means of the oesophagoscope. The obstruction was intermittent, and the oesophagus above dilated as in cardiospasm. The condition was kept satisfactorily under control by the periodic passage of a mercury bougie.

OESOPHAGEAL OBSTRUCTION FROM EXTRINSIC PRESSURE

A large number of extrinsic lesions may cause oesophageal obstruction. Chief among them are

Aneurism of the thoracic aorta

Neoplasm of the mediastinum, lung, or neck

Enlarged mediastinal glands

Abscess or new growth of the spine

Retro sternal goitre

Traction from fibrosed lung

Left sided interlobar empyema

Dysphagia lusoria

In general such sources of external pressure cause obstruction of the oesophagus only if they are situated in the neck or upper thorax. Their characteristics are described in the section on the thorax.



FIG. 19.—Oesophageal ectasia following a gross cervical phlegmon causing narrowing of the esophagus.

While fluids pass freely down a thick barium paste passes very slowly and with mild dysphagia.

ŒSOPHAGEAL DILATATION IN GASTRIC LESIONS

In certain gastric lesions such as carcinoma of the fundus, high hour glass contracture, high partial gastrectomy and other lesions causing marked diminution in the capacity of the stomach reservoir dilatation of the lower half of the oesophagus may occur. The dilatation is similar to that of

Gross pressure displacement of the gullet may take place in the lower thorax without causing any oesophageal symptoms.

In obstruction from such causes the oesophagus if filled with barium will be seen to be displaced and its lumen reduced at the site of pressure to a curved rat tail streak widening out below to a normal calibre.

IDIOPATHIC ATONY OF THE OESOPHAGUS

This rare condition has been described by Rosenheim and Hollenbeck and Oberle. It consists of a functional atony of the oesophageal tube without any organic or spastic obstruction.

a minor degree of cardiospasm, but the cardiac sphincter, instead of being closed, is widely patent (Fig. 19)

ŒSOPHAGEAL VARIX

This condition, although a comparative rarity, is now known to be less so than previously supposed, as a result of the recognition of its radiographic features. The varicose condition occurs in the lower part of the oesophagus and is caused by portal obstruction, in which condition it forms one of the channels of collateral circulation.

Oesophageal varix presents a characteristic appearance in a radiogram taken to show the mucosal pattern of the oesophagus. A fairly liquid opaque cream may be used, and the patient is best examined lying down. The varicose mucosal folds are then seen outlined with barium. A typical case cannot be mistaken for anything else. A colloidal barium water suspension is the best medium to use, since this tends to deposit on the tortuous rugæ. A Bucky grid should be used, to obtain the maximum contrast. Preliminary straining may help by keeping the mucosa "dry," and aiding the adhesion of the contrast medium.

THORACIC STOMACH

Complete thoracic stomach as a congenital abnormality, with correspondingly short oesophagus is rare.

Partial thoracic stomach is a less uncommon condition. Both are described in the section dealing with diaphragmatic hernia.

REFERENCES

- BARCLAY, A. E. *The Digestive Tract*, London, 1936
- BAPSON, T., *Klin. Wschr.* 1925 IV, 2500
- HOLZNECHT, G. and OLBERT, D., *Zeitschr. f. Klin. Med.*, 1910, LXXI, 91
- HURST, A. F. and RAKE, G., *Quart. J. Med.*, 1929-30, XXIII, 491
- LANGHEAD, F. S., *Brit. J. Child. Dis.* 1929, XXVI, 1.
- MATHIEU, A., and GOLDSMITH, H. L., *Amer. J. Surg.*, 1931, XXII, 273
- PALLIGRAT, J., *Röntgenpraxis*, 1932, IV, 761
- PATERSON, R. S., *Brit. J. Radiol.*, 1929 II, 331
- PAYNE, R. T., *Brit. J. Surg.*, 1931, XIX, 142
- PTIAN, L. N., *Brit. J. Surg.* 1933, XX, 508
- ROSENTHAL, T., *Zeitschr. f. Klin. Med.*, 1910, LXXI, 478
- SCHINZ, H. R., BAENZIGER, W., and KRIESEL, E., 'Lehrbuch der Röntgendiagnostik,' Leipzig, 1932

PART ONE

SECTION II

STOMACH, DUODENUM AND DIAPHRAGM

CHAPTER IV

GENERAL TECHNIQUE

THE X RAY examination of the alimentary canal is in the main bound up with the use of contrast media. The one in almost universal use now is barium sulphate. This has superseded the bismuth preparations—the carbonite and oxychloride—for two reasons, the pharmacological effect of the latter and the relative costs. The bismuth salts slow the rate of transit through the stomach and duodenum and are constipating in the colon. Their transit is about twice as slow as that of barium sulphate—a disadvantage from the point of view of examination of the stomach and duodenum. One advantage it possesses over barium sulphate is its soothing power in gastro intestinal lesions but barium sulphate has this to a slighter degree.

Other contrast media which find occasional use are thorium salts and air.

THE BARIUM EMULSION

The exact form of the vehicle of the meal is of no great consequence so long as it conforms to the following desiderata.

(1) Consistency. It must be fluid uniform in the distribution of the contained barium, and of the viscosity of a thin cream. For the examination of the oesophagus a thicker cream may be required.

(2) If for use in the investigation of the stomach and duodenum it should contain no food. The presence of food in the meal so delays the opening of the pylorus as to make it difficult to study the latter and the duodenum satisfactorily.

(3) Its taste and flavour must not be unpleasant.

(4) It must retain the barium salt in satisfactory suspension for a reasonable length of time. If properly proportioned it should maintain the suspension for an hour or two at least.

Various excipients have been used in the past. The first in common use was bread and milk, a bad one because of its irregular texture. Buttermilk, arrowroot, and other cereal preparations have been much in vogue, and still are.

largely used. In the writer's opinion they have the disadvantage, above referred to, of being foods. If this is not objected to, they make admirable media for the suspension. "Umbrose," a proprietary article containing, in addition to barium sulphate, dried milk, arrowroot, sugar, and chocolate, is widely used. Horlick's Shadow food is another very satisfactory food containing preparation, and may be used with advantage as the first or "motor" meal in the double meal technique (*vide infra*). Scott contributed a definite advance in technique when he devised the food-free barium emulsion, now so widely used.

The following are the formulæ which the writer uses:

BARIUM MEAL.

Barium Sulphate	ʒ 10
Saccharine	grs 2
Raspberry Essence	ʒl 45
Gum Tragacanth	grs 60
Aq ad	ʒ 1

BARIUM ENEMA.

(1) Barium Sulphate	ʒ 10
Gum Tragacanth	grs 40
Aqua Chloroformi	ʒ 5
Aq ad	ʒ 1
(2) Colloidal Barium Sulphate	ʒ 10
Aq ad	ʒ 1

For ordinary oesophageal examinations the above meal formula is satisfactory. In special cases its consistency may be stiffened by admixture of barium sulphate in powder form. The barium sulphate must be in the finest subdivision possible. It is now available in colloidal precipitation, and when in such form requires no tragacanth to suspend it, so fine are its particles. The degree of subdivision of any specimen of barium may easily be observed under the microscope. The particles should be fairly uniform in size. In equality in the size will render it difficult to maintain the emulsion for long. The average size of the particles can be graded microscopically against a colloidal specimen.

The barium emulsion is best made in an electric mixer. Hand mixing with a mortar and pestle is a laborious process, and much less efficient.

All the ingredients except the gum tragacanth should be sterilised, as should the container in which it is mixed, and the bottles in which it is stored. This applies particularly to the barium meal emulsion. Decomposition of this emulsion tends to occur on keeping it for long with the formation of traces of sulphides. This phenomenon is instantly detectable by the smell on uncorking the bottle. It may result from decomposition of the tragacanth, or from growth of mould on the surface of the liquid. Such an occurrence is satisfactorily prevented by the addition of chloroform water, in the case of the barium enema, but the taste of this ingredient is objected to by many patients.

and it is best omitted from a meal emulsion. Hence the necessity for sterilising as many of the ingredients as possible and the use of fresh emulsions only. Boiling the tragacanth destroys its emulsifying properties. Benzoic acid added to the amount of 25 a per cent, is an efficient preservative, but some patients object to its taste also and complain of slight stinging or smarting in the throat after swallowing a meal containing it.

TECHNIQUE OF THE BARIUM MEAL EXAMINATION

This is both fluoroscopic and radiographic. Both are of importance the latter the more so. It cannot be too strongly emphasised that the essence of a satisfactory X-ray investigation of the stomach and duodenum lies in the taking of an adequate series of radiograms. Not even the most prolonged and searching fluoroscopy should be accepted as a substitute for this. The two methods are complementary and while neither should be dispensed with in many cases a series of radiograms provides all the information necessary. The use of fluoroscopy alone however involves serious risk of an organic lesion remaining undetected.

The number of minor variations in barium meal technique is legion and an attempt to indicate them all would fulfil no useful purpose.

A complete technique should include radiographic study of both the completely filled lumen of the stomach and duodenum and also the relief pattern of the mucosa. The latter assumes a relatively greater importance in certain cases such as chronic gastritis and the stomach after operation particularly when sphincteric control has been abolished. Normally the study of the completely filled viscera is of greater importance but neither should be omitted.

Time Intervals in Barium meal Examination

There are certain time intervals after the ingestion of a barium meal which are radiographically important affording as they do the best opportunity for investigating successive portions of the alimentary tract. They form the basis of a routine technique and are subject to variations to meet special cases.

(1) IMMEDIATELY AFTER.—The first fifteen minutes after taking the meal is the vital period for the investigation of the stomach and duodenum. It is during this interval that the majority of peptic ulcers or carcinomata are best demonstrated and it is important to take a series of radiograms at this stage. The stomach and duodenum should first be studied fluoroscopically and radiographically after one mouthful of the medium to demonstrate the mucosal pattern. Immediately following this the filled viscera should be examined.

(2) ONE HOUR AFTER.—Examination at this stage serves to determine the presence of early gastric evacuation of a barium 'rest' to an ulcer crater of duodenal and upper jejunal obstruction and of the gastric mucosal pattern if this has not already been completely studied at the beginning of the meal.

(3) SIX HOURS AFTER—This is an important stage. It shows any pathological stasis in the stomach. It is now generally accepted that delay in emptying of a lesser degree than six hours has with some exceptions, little or no significance, while any considerable six hour gastric residue is usually of pathological import.

At this stage also the terminal ileum, appendix, caecum and right colon may be studied. The supine position is the most convenient for this purpose.

(4) TWENTY FOUR HOURS AFTER—The appendix may be better demonstrated at this time than at six hours and the colon to a degree varying according to the distribution therem.

(5) AT FORTY EIGHT HOURS AFTER and at succeeding daily intervals, depending on the rate of colonic emptying.

With the above desiderata in mind, the routine of a barium meal examination must be planned according to the time that can be devoted to it.

The routine of choice is to give a single meal and to follow it in a straightforward manner through the above stages. In hospital practice, if the radiologist is able to pay a visit of a few hours only in the afternoon, it may be impossible for him to examine the patient personally at every stage with a single meal technique and a compromise is sometimes adopted in the form of the double meal technique associated with the name of Haudek. In this the patient takes at home the first or motor, barium meal, usually of the cereal type, with a content of 6 oz. of barium sulphate. He attends the X-ray department six hours later. For example if the motor meal be taken at 8 a.m., the first attendance would be at 2 p.m. by which time the contrast medium will normally occupy the terminal ileum, caecum and right colon. After these portions of the tract have been examined and the presence or absence of gastric stasis noted, another meal is given and the stomach and duodenum investigated. The patient is seen again an hour later, and on the following day if necessary.

The method has the disadvantage that the first meal in the transverse colon may obscure the pyloric and duodenal regions to some extent.

PRELIMINARY PREPARATION

Aperients—This is a matter on which conflicting views obtain. Some radiologists order an aperient as a routine on the day before the examination, whilst others allow one to be taken if it is the patient's daily habit. The writer is opposed to both these courses, on the grounds that an aperient taken the day before is apt to disturb the normal (or pathological) transit of the meal through the alimentary canal. A safer plan is to avoid all aperients if possible, and if the patient's colonic habit makes some relief necessary, to give an aperient two days before, and an enema on the evening before the examination. An exception to this rule is when the appendix is suspect. An aperient tends to empty the appendix, and so ensure its subsequent filling with barium.

In such cases an aperient should be given as a routine on the day before the examination.

Drugs—All medicaments containing bismuth, phosphorus, calcium, or other drugs of a high atomic weight should be withheld during the examination, and for a day or two before. Magnesium carbonate and sodium bicarbonate may be taken as required.

Food—In the single meal technique the ideal is to withhold all food on the morning of the examination, if the first examination is to take place say, at 10 a.m. This is imperative if the patient be suffering from pyloric obstruction or stenosis. In some cases, however, this rule may be relaxed and the patient allowed a cup of tea and a small piece of dry toast two hours before the examination. Although this is a relaxation appreciated by the patient, it should be permitted only when the state of the stomach and duodenum is not in question.

Between the first sitting and that one hour later, no food or liquid should be taken. If a restorative such as brandy or sal volatile, is really necessary because of the patient's general condition it should not be withheld.

Between the one and six hour examinations it is the practice of many again to allow no food but this is in most cases an unnecessary deprivation, and unless there is present a gross gastric stasis a light lunch of fish or eggs is permissible without detriment to the investigation. Subsequent to this there are no radiological indications for dietetic restrictions.

The preliminary preparation for the double meal technique is similar, with the following variations. (1) In lieu of breakfast on the morning of the examination the cereal barium meal is taken. This contains food and so sustains the patient. (2) No food or liquid is allowed between this and the first examination six hours later.

In the later stages, when the colon is being studied, no aperient should be allowed.

In cases of severe colonic stasis however, this rule cannot be applied for too long. With each succeeding day, if no action of the bowels takes place, there is an increasing inspissation of the barium, with formation of scybala and if a partial organic obstruction be present in the left half of the colon a serious exacerbation may result from neglect of this point.

CHAPTER V

THE NORMAL STOMACH

ANATOMY

THE STOMACH is usually described in three portions—the fundus or pars cardia, body or pars media and pyloric antrum or pars pylorica.

The fundus lies above the level of the cardiac orifice or cardia, the pyloric antrum is the portion lying between the incisura angularis and the pyloric canal or pylorus and the body is represented by the intervening portion (Fig. 20).

Form of the Stomach—This is very variable depending chiefly on the habitus of the patient. It is usual to describe three types of stomach, hypertonic orthotonic and hypotonic corresponding to the three types of habitus—the hyper, ortho and hyposthenic. The normal stomach may show an infinite series of gradations between these limits and the criterion as to its normality in this respect is that it should conform to the general habitus. The three types of stomach are commonly likened to a steerhorn or cowhorn and a fish hook respectively.

Anatomical Relationships of the Stomach—Certain relationships are of radiographic importance. The fundus is in relationship above and behind with the diaphragm and in front with the under surface of the liver.

The anterior surface is in contact with the anterior abdominal wall. The posterior surface lies against the stomach bed composed of from above downwards the diaphragm, spleen, pancreas and duodeno jejunal flexure. To the left are the splenic flexure and the adjacent limbs of transverse and descending portions of the colon.

The stomach bed was previously held to be in posterior apposition to the whole of the stomach. Radiology has shown that the lower half of the stomach lies below those limits. The pancreas forms a transverse ridge which slightly indents the stomach near its middle so that in a lateral view the upper half of the stomach is inclined downwards and forwards whilst the lower half is perpendicularly disposed. An exception to this is the hypertonic type in which most of the stomach is apposed to the stomach bed. This pancreatic ridge is responsible for the posterior (pancreatic) incisura of Toldt described later.

TECHNIQUE OF EXAMINATION OF THE STOMACH

The examination should be commenced with the patient in the erect position in the screening stand. The patient is instructed to swallow a

mouthful of the barium cream, and this is observed in its passage into the stomach. With the right gloved hand this bolus is pushed into each part of the stomach in an attempt to "whitewash" the mucosa. In this way the mucosal pattern may be observed fluoroscopically, and an abnormality therein detected. After recording this radiographically in the supine or prone position, if the view in the erect position fails to show the pattern in the upper portion of the stomach satisfactorily the stomach is then filled, its filling being watched the while. As the capacity of the stomach varies, the amount of the barium cream necessary to visualise its lumen will also vary. An average amount is 10-12 oz.

When the stomach is filled, certain further points must be determined fluoroscopically, and should be noted as a routine. They are the position of the stomach, its tone and peristalsis, the flexibility of the gastric wall, and the presence of any persistent irregularity of its contours. The patient is then rotated into both oblique positions to bring into view the anterior and posterior walls of the stomach and at times a true lateral position may be necessary to show a posterior wall ulcer in profile. The pylorus may not be filled at first, but if not firm palpation with the gloved hand will serve to push some of the cream through it into the duodenum. Certain points should be noted in this important procedure.

It should be carried out with the tips of the four fingers of the right hand, by a progressive massaging movement upwards and to the patient's right. In the hypotonic stomach the pressure will be more conveniently exerted by the ulnar border of the hand and in an upward direction.

The pressure should coincide with a peristaltic wave, that is to say, when a wave has progressed about half way down the pars pylorica, and the pre-pyloric portion contains a rounded mass of barium. Immediately after this the pylorus tends to open of itself and little or no pressure may be required to fill the pyloric canal and duodenal bulb.

If the stomach is very hypertonic the pylorus and bulb may be hidden behind the superimposed shadow of the pyloric antrum. Rotation of the patient into the first or right oblique position (and, often, into the left oblique) will then bring these structures into view. Again, if the stomach be hypotonic and of the fish hook type the second portion of the duodenum may be directly behind the pyloric canal in the true postero anterior view, and a similar rotation of the patient be necessary to separate their superimposed outlines.

Frequently the resting stomach contains an ounce or two of secretion and the barium meal when taken is apt to float part of this up into the pyloric antrum where it is held trapped, as in the distal limb of a U tube. Such a state of affairs is evident as a horizontal barium level in the pyloric antrum. Before the pylorus and duodenal bulb can be visualised, this trapped resting juice must be forced through into the duodenum, a process which may require several palpatory manipulations each coinciding with a peristaltic wave. If

the pylorus be normal not more than half a dozen such manipulations are as a rule necessary.

During the fluoroscopy the relationship of any tender pressure points to the gastric and duodenal shadow should be noted and also the relationship of any tumour mass palpable clinically. As it is frequently difficult to feel such a mass with the examining hand encased in a thick lead rubber glove it may be necessary to mark the site of the mass by a ring of thin wire fixed to the abdominal wall with adhesive strapping. It is best to investigate this point with the patient supine and quite imperative that both procedures—the delineation of the tumour by the wire ring and the radioscopic palpation—should be performed without moving the position of the patient.

After the fluoroscopic examination has been completed it remains to take a series of radiograms. These are of prime importance because of the difficulty of detecting fine changes radioscopically and as one important proof of the organic nature of an abnormal appearance is in its constancy that constancy must be demonstrated in several radiograms. This is particularly applicable to the pylorus and duodenum.

The precise position of the lesion suspected will determine the position in which the radiogram is taken—e.g. for the fundus the supine position is the most suitable—but as a routine at least two radiograms of the whole stomach and duodenum should be taken and at least four of the pyloro-duodenal area. Some form of serial apparatus is desirable for these last. The *Beclère* serial apparatus and the *Berg* apparatus are admirable but require dual control. A convenient and simple form is that devised by *Riddell*. In the writer's modification of this there is an aperture 6×5 inches in the centre of a lead backed frame so arranged that the four quarters of a 12×16 inch film can be brought successively in front of the aperture and exposed. Four 6×5 inch radiograms of a suspected area are thus conveniently arranged on one film and can readily be compared one with the other. The disadvantage of this apparatus is that it is blind i.e. some few seconds must elapse between screening and the taking of the first picture. The *Berg* and *Beclère* types of apparatus on the other hand make it possible to radiograph a suspected area within a second of seeing it fluoroscopically and so enable one to choose the most satisfactory phase in a peristaltic cycle for the purpose of its demonstration.

Compression—Some form of compression is frequently required with the patient erect to demonstrate such points as the upper portion of a stomach which is hypertonic and in which the barium has sagged into a dependent pool to ensure complete filling of the duodenal bulb etc. The most useful for this purpose are a series of lambs' wool pads of various thicknesses and sizes. An obvious corollary of this is that the screen and cassette holder of the upright stand should be sufficiently rigid to exert firm pressure.

Berg has drawn attention to the necessity for what he calls graduated compression and aimed exposures in the radiographic demonstration of duodenal

ulcer He points out that a radiogram taken without compression may entirely fail to demonstrate a duodenal ulcer on the anterior or posterior wall of the duodenal bulb—*en face* in other words—while suitably applied compression may empty the duodenal bulb sufficiently to bring it into relief. He has devised for this purpose a special serial compression apparatus for use with an upright screening stand—the so called *Berg explorator*. This is undoubtedly the most satisfactory type of apparatus of this nature at the time of writing. A simple substitute is a pyramidal lambs wool pad. This is very effective when carefully applied. It is best made up of four square pads of lambs wool each in a calico cover and sewn together with tapes in the form of a step pyramid. The largest pad at the base of the pyramid is conveniently backed with three ply wood and the whole arrangement of pads enclosed in a pyramidal calico casing.

The *Chaoul compression band* in which pressure is exerted by the inflation of a hemispherical rubber band strapped by webbing to the abdomen is difficult in practice to apply accurately.

THE MUCOSAL RELIEF PATTERN OF THE STOMACH

It is only recently that much attention has been paid to this aspect of gastric and duodenal X-ray examination particularly as a result of the work of *Forsell Berg* and *Chaoul*.

Technique—Frequently the mucosal pattern can be demonstrated with the standard barium cream either after a few mouthfuls have been taken or at the end of an hour when the stomach is nearly empty. Excess of mucus or secretion may prevent this as will too thick a meal. In doubtful cases therefore in which a relief picture is of importance steps must be taken to ensure that the stomach is quite empty and a special contrast medium used. The examination is best conducted early in the morning with the patient fasting overnight. A thin colloidal barium cream with no tragacanth may be effective or a thorium oxide suspension such as diagnothorine. This is a colloidal suspension which is supposed to flocculate on reaching the mucosa and so to produce a thin coating over its surface. About $\frac{1}{2}$ to 1 oz of either of the above media is sufficient and should be taken lying down. Too much obscures the pattern. The patient then lies on each side and then prone to coat the whole mucosa.

Screen examination will show the best position for a radiogram usually prone.

In the study of the mucosal pattern the following points must be noticed

- (1) Complete absence of the rugae as in atrophic gastritis or limitis plastica
- (2) Localised absence as in carcinoma
- (3) Interruption and puckering from ulcer
- (4) Increase in size of the rugae and increased tortuosity both met with in hypertrophic gastritis

(5) Abnormal persistent flecks or barium rests in an ulcer crater or carcinomatous crevice

AIR INSUFFLATION OF THE STOMACH

Dugal and *Beclere* have developed a technique for investigating the stomach after distension with gas. In their method an Einhorn tube is swallowed by the patient. The stomach must be quite empty, and any fluid residue should first be drawn off through the Einhorn tube. The stomach is then slowly inflated under fluoroscopic control. Care must be taken to avoid undue distension. The inflation apparatus may with advantage include a pressure gauge and if the patient experiences any pain during the inflation, the administration must be stopped and a little air released from the stomach.

This method is of greatest value when combined with a whitewash method—the *couche mince* of these authors. The thin coating of barium or of thorium on the mucosa throws it into greater relief when there is the added contrast of the air distension. Erect, prone, supine, lateral, horizontal and Trendelenburg positions may all be necessary in different cases, depending on the site of the lesion to be studied. A tilting table is of great convenience in this technique.

The "blind" method of insufflation, by Seiflitz or similar powders, is unsatisfactory, since the degree cannot be controlled, and fluid is introduced at the same time.

These authors state that valuable information may be obtained regarding

ENCEPHALOID CARCINOMA—In this condition the mass may be seen protruding into the air filled lumen and the site of origin of the growth may be determined.

GASTRIC POLYPI—According to those authors, the number and disposition of the polypi can be determined, and pedunculation made out.

IN PERTIC ULCER this procedure is contraindicated, for fear of perforation.

PANCREATIC TUMOUR—A lateral radiogram, taken with patient lying prone, may show the tumour mass projecting into the gas filled stomach.

The method is as yet relatively untried, and at the majority of cases it is improbable that it offers advantages over the more established methods commensurate with the risks of perforation and the unpleasantness of swallowing the Einhorn tube. In certain cases of exceptional difficulty or obscurity it may, however, be a diagnostic measure of considerable value.

The most convenient time to conduct the pneumogastric examination is in the evening, six to eight hours after the ordinary barium meal. The patient should fast during that day.

NORMAL APPEARANCE OF THE STOMACH IN THE ERECT POSITION

Before the meal is given the gastric fundus only is visible, outlined by gas. This gas bubble, variable in size to some extent, may disappear if the

stomach is empty. If there is any considerable amount of resting juice in the stomach the gas bubble may be limited below by a horizontal fluid level.

When the opaque cream is swallowed it is held up for a few seconds on passing into the stomach just below the cardiac orifice and gradually slides down the lesser curve to the lower pole. In an empty stomach of good tone the barium does not form a pool at the lower pole but canalises the stomach as more of the meal is taken until gradually the whole gastric lumen is distended and filled with the opaque medium with the exception of the gas filled fundus. The upper level of the barium emulsion forms with the gas above it

a horizontal level and any secretion already present in the stomach forms a superficial fluid layer between the two.

Cardiac Orifice — In most cases in the erect position this orifice is above the level of the barium but if the gas bubble be very small or absent it will be visible as a puckered projection of the barium shadow. Immediately below it there is sometimes a projection to the left of the lesser curve which may simulate an ulcer niche. Indeed it may be impossible to differentiate radiographically between them. The cardiac orifice is however best demonstrated in the supine position.

The Lesser Curve presents with the above exception a smooth regular contour down to the incisura angularis where it turns upwards on itself the acuteness of this blunt angulation depending on the type of stomach. From the incisura angularis to the pylorus the lesser curve is similarly regular but sometimes presents a small notch about $\frac{1}{4}$ inch in depth a little short of the pyloric canal. This is due to a mucosal fold and is not pathological. Any irregularity of the lesser curve either a protrusion or a defect should be regarded as representing an organic lesion until it is proved to be the reverse.

The Greater Curve, on the other hand is more variable in its contour. Normally smooth and undulated by peristalsis it may present a notched appearance from several causes one of which not being pathological concerns us here. If the colon in the region of the splenic flexure be deeply invaginated and be lying closely apposed to the greater curve of the stomach it may produce a series of indentations in the latter corresponding to the haustral bulges in the colon. This type of indentation has to be distinguished from those caused by increased rugosity of the gastric mucosa and gastrospasm respectively.

The Lower Pole is high in position and of mild convexity in the hypertonic stomach and low and parabolic in outline in the hypotonic. In very hypotonic stomachs its contour becomes bulbous the barium tending to form a pool in it. This degree is probably over the borderline of the normal. The limits

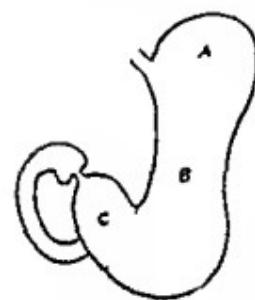


FIG. 9.—Schematic drawing of the stomach: (a) Fundus or pars cranialis; (b) Body or pars media; (c) Stomach antrum or pars pylorica.

ness of this blunt angulation depending on the type of stomach. From the incisura angularis to the pylorus the lesser curve is similarly regular but sometimes presents a small notch about $\frac{1}{4}$ inch in depth a little short of the pyloric canal. This is due to a mucosal fold and is not pathological. Any irregularity of the lesser curve either a protrusion or a defect should be regarded as representing an organic lesion until it is proved to be the reverse.

The Greater Curve, on the other hand is more variable in its contour. Normally smooth and undulated by peristalsis it may present a notched appearance from several causes one of which not being pathological concerns us here. If the colon in the region of the splenic flexure be deeply invaginated and be lying closely apposed to the greater curve of the stomach it may produce a series of indentations in the latter corresponding to the haustral bulges in the colon. This type of indentation has to be distinguished from those caused by increased rugosity of the gastric mucosa and gastrospasm respectively.

The Lower Pole is high in position and of mild convexity in the hypertonic stomach and low and parabolic in outline in the hypotonic. In very hypotonic stomachs its contour becomes bulbous the barium tending to form a pool in it. This degree is probably over the borderline of the normal. The limits

of the normal level of the lower pole are a matter of dispute. The intercrestal line (the modern equivalent of the old halfpenny on the umbilicus) was formerly given as the lower normal limit but it is now recognised that lower levels are compatible with normal health. Probably a point half way between the intercrestal and pubic levels marks the normal lower limit.

The Pylorus, when seen in profile is a short regular canal about $\frac{1}{4}$ inch in length. Its contours are perfectly smooth and join the lesser and greater curves in blunt right angles. Its calibre as seen in a radiogram depends on the degree of relaxation of the pyloric sphincter and varies from nil up to 0.6 mm. The pyloro duodenal junction is also normally very regular often geometrically so and can be compared with the junction of the stem and body of a mushroom.

The direction of the long axis of the pyloric canal depends on the type of stomach. In the hypertonic type it is directed backwards to the right and slightly upwards. In the orthotonic it is upwards slightly to the right and slightly backwards while in the hypotonic type it is either directed upwards or upwards and slightly to the left.

The position of the pylorus in the abdomen also varies with the type of stomach. The lesser the tone the lower its level is. Normally it varies between a point midway between the xiphisternum and umbilicus and the umbilicus itself. It is held by some authorities that it descends to a lower level only in cases of gastropathy.

Tone of the Stomach—Apart from pathological variations the gastric tone follows the habitus of the individual being greatest in the hypersthenic



FIG. 1.—Normal orthotonic stomach.

individual, and least in the hypotonic. Its estimation is simple when the stomach is filled with barium emulsion, by comparison of the relative widths of the upper and lower parts of the gastric lumen, and the general conformation of the stomach.

In hypertonus the stomach is "steerhorn" in shape, its lumen largest above, and tapering to the pylorus. The incisura angularis is feebly represented, and the greater curve descends only a small distance below the pyloric level. Indeed in marked hypertonus the pylorus may be the lowest point of

the stomach (Fig. 22)

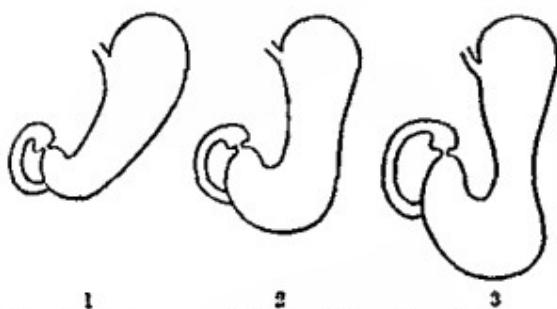


FIG. 22.—Three normal types of stomach. 1 Hyper tonic. 2 Orthotonic and 3 Hypotonic

greater curve at the lower pole tends to sag down, making the lumen there larger than elsewhere. The lumen of the pars media collapses from incomplete filling and dragging. The most dependent portion of the greater curve may reach half way between the umbilicus and symphysis pubis.

Apart from habitus there are various other factors which modify gastric tone. Vagal stimulation increases it and sympathetic stimulation does the reverse. Psyche factors may have a marked temporary effect. Fear and depression diminish tone as does nausea from an unpleasant taste—e.g. of a badly flavoured barium meal! Conversely it increases during excitement.

The effect of gastric biliary and duodenal lesions is variable but as a rule the first depresses it. If a gall bladder lesion has any effect, it is usually depressing while a duodenal lesion may do either.

Peristalsis—The peristaltic waves in the stomach begin high up in the pars media where they are very shallow. As they spread downwards they become deeper but this deepening is chiefly on the greater curve until the incisura angularis is reached. Above that point the peristaltic undulations of the lesser curve are very small. By the time it has passed the incisura angularis the wave has become deep, and about midway between that point and the pylorus completely obliterates the gastric lumen trapping a portion of the gastric contents in front of it. If the pylorus has not opened, a reflux takes place past the peristaltic ring but after a few such abortive waves the pylorus opens, and a mass of barium is expelled into the duodenal bulb, which it fills

In orthotonus the stomach is J shaped, the incisura angularis is fairly well marked, and the lower pole of the stomach about equal in calibre to the upper portion of the pars media. The most dependent portion of the stomach lies about the intercostal level.

In the hypotonic stomach

its form is fish hook. The

Successive waves form behind each other at such rate that two or three are visible in the stomach at any instant

It is held by some that the initial wave occurring after a resting phase when food is taken commences at the level of the *incisura angularis*, that is at the lower pole where the first distension of the gastric wall by food takes place. The writer has not been able to satisfy himself that this is the case.

Apart from obstructive atony of the stomach the gastric peristalsis is related to its tone being most marked in hypertonus and least in hypotonus. In the exception mentioned above the stimulus of food usually induces a short bout of violent hyperperistalsis followed by complete cessation.

Hyperperistalsis is not a physiological condition. It may be due to a number of causes and is of two types obstructive and non obstructive. The former occurs in pyloric and duodenal obstruction (*q.v.*). Non obstructive hyperperistalsis is most commonly due to duodenal ulceration but may result from a biliary or appendicular lesion and in aeliolitydria. It shows in a radiogram by a larger number of waves smaller than the normal. Instead of two or three waves there may be as many as six or seven present at the same time. The length of each wave is smaller and the rate of progression faster (Fig. 23).

The "Antral Sphincter." — After much conflict of opinion the existence or not of this sphincter, which has for years been described by physiologists has



FIG. 3.—Gastric hyperperistalsis.

been decided in the negative, chiefly as a result of the cinematographic work of *Forsell* and *Kaestle*. The appearance of the splineter is due merely to the deepening of the pyloric waves in the pyloric antrum. As one sweeps on towards the pylorus, another forms behind it, and the progressive nature of these contractions rules out the theory that there is any true spluneteric action.

Cascade Stomach (*syn. "cup and spill"*, *physiological hour glass*, *estomac en coupe à champagne*)—This curious appearance is one of loculation and marked dilatation of the fundus. The contrast medium

passes through the cardia into the fundal loculus, the lower part of which it fills. It then spills down into the lower part of the stomach, a semi-elliptical pool remaining above. Ballooning of the fundus is a common feature in these cases (Figs. 24 and 25).

The lateral view shows the loculation to be due to the posterior wall of the stomach forming a shelf, which traps the meal in a shallow trough. When this is filled to the brim the barium spills over in front and fills the lower stomach. At times the lower portion of the stomach is rotated and displaced to the right, and drawn upwards. In other cases only the upward displacement exists.

Several causes are assigned to this condition:

(1) **DISTENSION OF THE SPLENIC FLEXURE WITH GAS**—This, causing

pressure on the posterior wall of the stomach just below the level of the cardiac orifice certainly accounts for a certain number of cases. Dispersal of the gas results in the stomach assuming its normal position and contour.

(2) **LOCALISED MUSCULAR HYPERTONIA**, with associated fundal ballooning, particularly of a band of oblique fibres in the lower posterior part of the fundus. The cause of this is unknown.

(3) **LOCALISED SPASM** and

(4) **CONTRACTION OF PERIGASTRIC ADHESIONS** may produce a similar appearance but, as pathological lesions, should be excluded from the classification of "cascade stomach".



FIG. 24.—Mild degree of cascade stomach.

Not infrequently the cascade effect is so gross as to produce a complete hour glass appearance. In cases of this degree the splenic flexure is usually coiled in the left cupola. Another curious effect that is occasionally produced is a blunt projection high up on the lesser curve. It must not be mistaken for an ulcer.

NORMAL APPEARANCES IN THE SUPINE POSITION

With the subject in this position the spine and structures in front of it act as a watershed separating the contents of the stomach in two unequal portions, a small pyloric and a large fundal. Most of the opaque meal falls back into the fundus and this position is the most satisfactory for the demonstration of that portion. The contour of the fundus may be quite regular and smooth or may show a series of indentations regular in character from mucosal folds. The presence or absence of these mucosal notches depends on the degree of the gastric tone at the moment and the amount of its contents (Fig. 26).

The *pars media* is as a rule incompletely filled. Any gas present tends to collect in this the highest part of the stomach in the supine position. As a rule the rugae are visible front a coating of barium. The stomach has a higher and more transverse disposition in this position than in the erect. The duodenum is likewise higher. This postural displacement upwards varies in degree from 1 to 4 inches or more depending largely on the tonic type. It is greater in the hypotonic.

The pyloric antrum usually contains a small amount of the opaque medium, in a mass separate from the fundal pool. If, however, gastric tone be marked,



FIG. 26.—Marked cascade stomach postero-anterior and lateral views.

and if no gas be present the two shadows may be joined by the barium filling up the pars media

If there is a sufficiency of barium in the pyloric antrum the pyloric canal and duodenal bulb may be well visualised as a rule however they are better seen in the erect or prone postures. The supine frequently fails to provide a column or head of barium cream sufficient to promote complete filling of the duodenal cap.

F H Twining in a personal communication has drawn attention to an anatomical variation which he calls the posterior (pancreatic) incisura. He



FIG. 6 Normal stomach appearance in the supine position

ascertained by studying the stomach in lateral films in the supine position that the pancreatic ridge often causes an infolding of the gastric wall. If this infolding reaches the surface of the barium (in the supine position) an incisura is formed which may either cross the stomach or only reach half way across it. Behind this infolding of the gastric wall a triangular filling defect is present respecting the body of the pancreas itself (vide section on pancreas). The infolding therefore simulates a true spastic incisura in the supine position anterior view from which it may be distinguished by two features (a) it is crossed by mucosal folds (b) it disappears in the prone position. It occurs usually in puerperal women.

NORMAL APPEARANCES IN THE PRONE POSITION

In this position the gravity relationships are reversed. The fundus is much the highest, the pars media and pyloric antrum in front of the spinal column the most dependent, and the pylorus and duodenum intermediate. Most of the opaque medium will therefore tend to gravitate to the pars media and pyloric antrum, and gas in the stomach to rise to the fundus and pyloris. All the gas can be collected in the fundus by asking the subject first to lie on the right side before turning into the prone position.

The fundus will therefore be incompletely outlined. The mucosal pattern of the fundus, however, frequently stands out well (Fig. 27). The pars media and pyloric antrum are well outlined, and peristalsis in them is usually more active than in the erect position. The pyloric canal and duodenum nearly always fill satisfactorily. In this view quite well-marked peristaltic waves are seen on the lesser curve. Indeed, in the very hypotonic types of stomach this may be the only position in which to see these two structures properly outlined. If, as occasionally happens, the pyloric antrum overlies the pyloric canal, slight rotation of the subject will separate the two shadows. The mucosal pattern of the pars media is easily demonstrated in this posture by the insertion under the epigastrium of a wool pad of suitable thickness. The exact size must be determined by trial in each case.



FIG. 27.—Normal mucosal pattern of fundus and pars media prone position

NORMAL APPEARANCES IN THE ERECT LATERAL VIEW

In a true lateral view the gastric shadow presents a mildly bilocular appearance—two oval cavities connected by a narrower isthmus. It may be compared with an old fashioned sac purse. The upper or fundal loculus slopes downward and forwards, the lower loculus hangs vertically downwards. This applies particularly to the hypotonic stomach. For the hypertonic type there may be seen no such biloculation. The pyloric canal is not visible in the true lateral view; a little rotation will bring it into view in front of or behind the stomach. Behind the lower pole of the stomach will be seen the duodenum and duodeno-jejunal flexure.

This view of which owing to the relative thickness it is difficult to obtain very sharp radiograms is chiefly of value in the demonstration of anterior or posterior wall lesions or to obtain profile views of the stoma and adjacent loops in cases of gastro jejunostomy anterior or posterior

THE GASTRIC MUCOSA

The classic description of the gastric rugae is as follows

Four longitudinal rugae two anterior and two posterior, begin at the cardia and run down close to the lesser curvature to end at the pylorus. These four are described as forming the *magenstrasse* under the impression that they

constitute the channel for the downward passage of food to the lower pole to the exclusion of the rugae nearer to the greater curve. This exclusive action of the *magenstrasse* is a myth. Three or four additional longitudinal rugae on each wall are described between the *magenstrasse* and the greater curvature. These begin in the fundus of the stomach and end in the lower pole (Fig. 28). The longitudinal rugae become increasingly irregular the nearer they are to the greater curve and show a tendency to become broken up into secondary transverse and oblique rugae (Figs. 29 and 30). Chaoul regards this



FIG. 28. Normal mucosal pattern in stomach of rather a fine type.

arrangement to be static and modified only by the elastic stretching and contraction of the mucosa as a whole in response to varying distension of the stomach.

The modern view however on the form and functions of the gastric mucosa is based on the researches of Forssell. In 1923 this worker first stated his autoplastic theory that of the automatic functional motility of the gastric mucous membrane and thereby gave a satisfactory reason for the existence of the muscularis mucosae. Prior to his paper that muscular layer was not known to have any significant functional activity. Forssell's theory is

in brief, that the gastric mucosa can adapt its rugae, in response to the stimulus of food, into such a form as is best suited to promote digestion, and that this activity is a local autonomic response, and not dependent on distant nervous control. The particular value of his work lies in the attention he has drawn to the great variation which may occur physiologically, and to the changes which may take place in gastric disease.

Forsell's work extended also to the duodenum, small intestine and colon, although it is in the stomach that the phenomena can best be studied.

Berg and *Albrecht* have elaborated his work, and recently *Kadrnka* has given an account of the physiological changes that may occur.

Chaoul does not accept *Forsell's* views, and holds that the rugosity of the gastric mucosa is governed by the distension of the viscera but the latter's views are probably nearer the truth. It is possible that both are to some extent right, that the longitudinal rugae along the lesser curve are anatomical, that those near the greater curve are autophistic, and that both factors control the intermediate ones.

The mechanism of the physiological changes in the gastric rugae is, according to *Forsell*, twofold—the autonomic activity of the muscularis mucosae and the varying vascularity of the mucosa and submucosa. The former determines the number and shape of the folds, and the latter, by a varying degree of turgidity, controls to some extent their size and coarseness.

Kadrnka has described the following changes in the gastric mucosa under varying physiological and pathological states:



FIG. 29.—Normal mucosal pattern of stomach, duodenum and jejunum.

Physiological

(1) MODIFICATIONS RESULTING FROM PROGRESSIVE DISTENSION WITH BARIUM EMULSION.—When the stomach is relatively empty the rugæ are few and coarse. As the viscous is filled the transverse rugæ become smaller but at the same time more numerous. This occurrence is inexplicable by *Claud's* theory. If the gastric rugæ were dependent on the contractility of the muscular coats distension would obviously efface them gradually but would not add to their number.



FIG. 10.—Normal mucosal pattern in stomach
delineated with colloidal barium.

(2) MODIFICATIONS DUE TO THE PRESENCE OF FOOD IN THE STOMACH

—This when tested by the addition of yolk of egg to the thin contrast medium resulted in enlargement of the mucosal folds and their re-arrangement. In this connection *Forsell* described in the dog the formation of actual mucosal po囊ets surrounding particles of meat to which he gave the names of *fossuettes* or *alveoles digestives*. The muscular, mucose and vascular engorgement are both said to take part in the formation of these lacunæ. These fossuettes do not occur in the human subject. Experimentally it was found that if the ingested meat is in comparatively large fragments the enlargement of the rugæ is considerable in the attempt to engulf them.

(3) INFLUENCE OF EXTRANEAL FACTORS

—Cold tends to make the rugæ smaller and more numerous both in the stomach and colon. Pilocarpine has the same effect and atropine the opposite. These changes are however not constant.

In the colon castor oil tends to enlarge the rugæ by vascular congestion while saline purges by dehydration have the reverse effect.

Pathological

The changes in the appearance of the gastric mucosa in different diseases of the stomach are described under their respective headings but may be summarized as follows:

EXTRINSIC PRESSURE—Displacement spreading and disappearance of the folds These changes occur only when the pressure is considerable

INFLAMMATION—Thickening irregularity and stiffness of the rugæ According to *Berg* a verrucose stage may be reached in chronic inflammation In atrophic inflammation no change is visible as a rule In gross atrophy they may disappear

ULCER—Convergence of folds (which may be thickened) on the crater Erosions are usually undemonstrable

NEOPLASM—Obliteration of the rugæ and irregular protuberances and craters on the growth itself

RATE OF GASTRIC EVACUATION

In the consideration of this there must be noted

- (1) The time of commencement of evacuation
- (2) The time of evacuation of the main bulk of the meal
- (3) The time of evacuation of every trace of the meal

Variation in the time of all three may occur according to the type of stomach the type of meal and the pyloric function

Taking as a standard the orthotonic stomach a normal pyloric function and a food free barium cream as the contrast meal gastric evacuation should commence in about one minute after ingestion of the meal The main bulk of the meal should have left the stomach in an hour and every trace in two to three hours Frequently the last time factor is lengthened even in the normal and there may be retained in the stomach a small trace of barium up to six hours If the above first and second time intervals are normal the latter is of little significance provided the patient is fasting and has not been lying down A small six hour residue is common in hypotonia and results from gravity It can as a rule be freely expressed through the pylorus by manual pressure thus differentiating it from a residue due to pyloric obstruction spasm or achalasia A poorly suspended barium emulsion tends to produce a streak residue at the lower pole by sedimentation This is completely prevented by the supine posture and is not seen in cases confined to bed

Haudek first laid down the rule that a six hour gastric residue indicates a pathological condition but this is true only if the residue be of some size say one fourth to one third of the meal and even then it may be due merely to gross hypotonia and ptosis and not to pyloric obstruction

The Influence of Various Factors on Gastric Evacuation

- (1) **TYPE OF MEAL**—The presence of any food and particularly fat lengthens all three times Barium in place of barium has the same effect and is said approximately to double the time of evacuation compared with barium

(2) TONICS OF THE STOMACH—Hypertonus speeds up the second and third time intervals, and hypotonia slows them. Neither has very much effect on the time of commencement of evacuation, unless the hypotonia be so marked as to approach atony.

(3) PERISTALSIS OF STOMACH—The degree of peristalsis influences all three times directly.

(4) PYLORIC FUNCTION—Variation in the normal pyloric function affects all three points in the rate of evacuation.

(a) *Undue Patency*—This may be organic, as in a scirrous carcinoma of the pylorus or functional, as in a carcinoma not involving the pylorus or a simple achylia. In each case the stomach empties rapidly.

(b) *Achalasia of the Pylorus**—This term is used by Hurst to describe a condition in which the pylorus relaxes infrequently by itself while pressure readily forces food through into the duodenum. It delays the evacuation times.

(c) *Pylorospasm*—In this reflex condition, most commonly the result of a gastric or duodenal ulcer the pylorus is obstinately shut at first, and after about fifteen minutes commences to relax and allow free gastric evacuation. Pylorospasm therefore affects principally the first time factor, that of commencement of evacuation, and the other two to a lesser extent. It at first simulates organic obstruction, a simulation disproved by the later course of evacuation.

(d) *Organic Obstruction*—With this all three times are markedly lengthened. The last factor may spread over into the following day—a state of affairs practically pathognomonic.

THE ACT OF VOMITING

If the stomach be observed under the screen during the act of vomiting the following sequence of events is seen:

The diaphragm rises with the increase in abdominal pressure. The body and pyloric antrum contract vigorously and the stomach takes on a peg top shape. The fundus remains dilated and the gas bubble disappears with the opening of the cardiac sphincter. Combined contraction of the abdominal muscles diaphragm and stomach ejects the gastric contents up the oesophagus. After the act has been completed the stomach gradually relaxes and assumes its normal contours.

CHAPTER VI

GASTRIC ULCER

RADIOLOGY HAS revolutionised the diagnosis of peptic ulcer, and its differentiation from other organic disease in the abdomen and from the functional dyspepsias. It has removed this lesion from the realm of diagnostic guess work and established it as one of the most easily diagnosed, in the ordinary type of case.

The barium meal examination, if thoroughly and efficiently carried out, is by far the most accurate method of investigation in suspected peptic ulcer, and in the majority of positive cases demonstrates the lesion beyond all doubt or argument. This supremacy as a diagnostic method is of comparatively recent growth, and is dependent on careful and accurate technique. In the hands of the inexpert or careless it can be so misleading as to be dangerous. This last requires emphasis now in a way it did not twenty years ago. Twenty years ago, or even later, radiological investigation of the stomach was so much in its infancy that undue reliance was not placed on its results. Nowadays the profession has been educated to rely on the accuracy of the radiological method in organic gastric disease to such an extent that, unless the clinician is also versed in the technical aspect of radiology to some extent, he may be misled by inefficient radiological investigation in a way that would not have been possible in the past.

Peptic ulcer may occur in any of the following sites—oesophageal, gastric, pyloric, duodenal, jejunal.

Oesophageal peptic ulcer is rare, and has been mentioned in the section on the oesophagus.

Gastric and duodenal ulceration are, on the contrary, common conditions, and constitute by far the commonest lesions found by X-ray examination of the stomach and duodenum. Of the two, duodenal ulcer is the more common.

Walton has pointed out the very varying ratio between gastric and duodenal ulcer recorded by different authorities, which he quotes as follows:

	G.U. Percent	D.U. Percent
Pick	27	73
Mayo	26	74
Morison	24	76
Sterren	54	56
Walton	59	41

Walton's figures for duodenal ulcer are surprisingly low. The writer's figures, in common with those of many other radiologists, are of the order of 4 to 1.

Duodenal and jejunal ulcer are described in their appropriate sections.

PATHOLOGY OF GASTRIC ULCER

Gastric ulcer may be acute subacute or chronic. It is now held that all peptic ulcers of the stomach begin as acute erosions.

The acute stage lasts up to three weeks then if the ulcer does not heal becomes subacute and reaches the chronic stage if it still persists in two months.

Acute Ulcers or Haemorrhagic Erosions are commonly multiple. They vary in size from a pin head to an inch in diameter may occur irregularly distributed anywhere in the stomach but are commonest in the pyloric half. They are shallow and rarely involve the muscular coat. Oedema may occur round the ulcer and cause an apparently deep crater. They tend to heal rapidly in two or three weeks.

Subacute Ulcers are merely a temporary transition stage between the acute and the chronic. They are fewer in number than the acute (most of which heal) and may be single. The muscular coat shows commencing involvement and some basal inflammatory reaction is present.

Chronic Gastric Ulcer—This is the type which is usually presented for X-ray examination.

They are usually single. The following data have been compiled by *Hurst and Steerart*.

(1) **SINGLE** in 97.5 per cent of cases.

(2) **POSITION**—

Lesser curve region	Percent
Pyloric canal	8.4
Cardia	1.2
Anterior wall	1
Posterior wall	3

The lesser curve region includes those on the anterior and posterior walls close to the lesser curve.

(3) **SIZE**—The average size in 186 cases they investigated was 16 × 10 mm according to the Mayo Clinic 94 per cent showed a diameter less than 2.5 cm.

(4) **FORM OF THE ULCER**—This depends on the stage.

When active the ulcer is deeply excavated sometimes globular and with thickened overhanging edges. The surrounding mucosa is oedematous. *If silent* the thickening and oedema of the margin diminish but still overhang until the *healing stage* when the ulcer gradually assumes a conical shape.

(5) **FLOOR OF THE ULCER**—When the muscular coat is breached granulation tissue and later fibrosis form a new floor most commonly in the thickened gastro hepatic omentum. The pancreas forms the bed of the ulcer in 4 per cent of cases and the liver in 1 per cent. When these structures form the bed the ulcer is as a rule shallower than when the gastro hepatic omentum forms the floor.

(6) ADHESIONS OF THE ULCER BED.—The peritoneum covering the floor of the ulcer responds to inflammatory irritation by a localised plastic peritonitis causing adhesions to neighbouring structures. The adhesions may cause some deformity and by retraction of the lesser curve upwards and to the left contribute to an hour glass location.

RADIOLOGICAL FEATURES OF GASTRIC ULCER

The X-ray signs of gastric ulcer fall into two classes—direct and indirect. There are many indirect signs of varying value. There is only one direct sign, but it is virtually pathognomonic and will be considered first.

THE DIRECT SIGN OF GASTRIC ULCER

This consists of the demonstration of the ulcer crater—the niche of *Handel*. In its most typical and most easily demonstrated form it consists of a protrusion of the barium shadow from the lesser curve. This is at once evident when the stomach is filled with a contrast meal. It is not necessary for the ulcer crater to be situated precisely on the lesser curve to be so visible. It will be seen even if on the anterior or posterior wall if not more than an inch or so from the lesser curve if it be in an active stage as spasm and oedema bring it into profile. Again rotation of the patient in the appropriate direction will show a crater in profile if it be masked in a true postero anterior view (Fig. 31). As a preliminary however to this the most certain demonstration of an ulcer crater the relief pattern of the gastric mucosa should be studied by the white wash method of Gilbert Scott. This frequently shows the ulcer crater filled and directs attention to it before filling the stomach completely—a procedure which in certain cases masks a posterior wall ulcer.

Appearances of the Crater in the Mucosal Pattern Radiogram

The relief pattern is of particular value in the study of ulcers in sites where a profile view of the crater is difficult or impossible to obtain such as the anterior or posterior wall and in or near the fundus. The ulcer crater visualised in such a radiogram will vary in its appearance according to its degree of activity. Assuming that the crater is on the posterior wall and the radiogram taken with the patient supine there will be visible

(1) A CENTRAL FLECK—the barium filled crater the *tache suspendue* of the French.

(2) A ZONE AROUND THIS DEVOID OF BARIUM—This represents the oedematous mucosal lip of the crater. The width of this zone forms an index of the activity of the ulcer or more precisely of the surrounding mucosal inflammation. The wider this transparent zone the greater the oedema.

(3) FINALLY A CORONA OF MUCOSAL RUGAE converging towards the crater. The convergence again is an index of the chronicity of the ulcer. The

convergence is the result of cicatrical contracture round the crater and is present only in ulcers which have reached the chronic stage (Figs. 32 and 33).

Appearances of the Ulcer in the Filled Stomach

With the stomach filled with barium cream and the patient erect the ulcer



(a)

(b)

FIG. 31.—Fundic wall ulcer. (a) Clearly visible in view of its size. (b) Almost entirely hidden in postero-anterior view of the filled viscera.

crater seen in profile may present a wide variety of appearances depending on its size, depth and activity.

ACTIVE CHRONIC ULCER—The crater filled with barium appears to be deep and often with a rather narrower neck and a rolled-over edge. The depth may be so considerable that it appears almost certainly to have penetrated right through the gastric wall into the perigastric tissues (Fig. 34). At operation the appearances are as a rule very different—a comparatively shallow



FIG. 32.—Posterior wall ulcer crater seen *en face*. Well marked rugal corona.

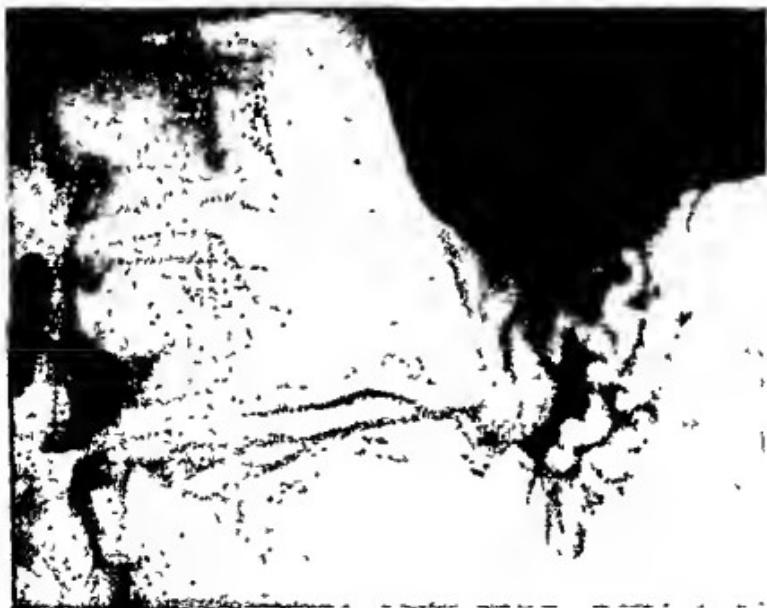


FIG. 33.—Posterior wall ulcer, showing rugal corona on compression.

ulcer, with no suspicion of penetration through into the perigastric tissue. *Forsell* first suggested the explanation of this discrepancy.

X-ray examination usually takes place during or immediately after an active phase of the ulceration—is indeed often precipitated by an especially severe bout of dyspepsia and the stomach is therefore examined when its mucosa is edematous and edematous round the ulcer.

Operative interference on the other hand as a rule takes place after the



FIG. 34.—Large active liver curve ulcer with oedematous edges.

patient has had some days or weeks of treatment with the result that the associated gastritis and oedema of the mucosa round the crater has subsided when the ulcer is inspected at operation (Figs. 35 and 36).

It is then the oedema round the crater that is responsible for its depth and the degree of the oedema can frequently be determined with accuracy by visualizing the normal line of the lesser curve. It will then be seen that the deepest part of the crater lies on that line and that the pathological lesser curve sweeps well to the left in a blunt mound on the summit of which is the neck of the crater. The estimation of the size of this mucosal hillock is of



Dog 36—Lesser et rvo ulcer crater



Dog 3—S1 or letter box ulcer crater on face. Note absence of mucosal remains in late healing stage

importance in judging the degree of gastritis and its healing under medical treatment

If as a result of the above factors the ulcer crater is very deep locular and with a narrow neck an appearance in the erect position results which was previously described as diagnostic of chronic perforation and formation of a perigastric cavity. Three layers are then visible in the cavity—air fluid and

barium—from above downwards. The somewhat clumsy term accessory pocket has been applied to this appearance. This lamination is also seen in true perigastric cavities resulting from chronic perforation. They however tend to be larger and may not have the characteristic position of the former relative to the lesser curve (Fig. 37)

A flock of barium very typically remains in the crater after the stomach has largely emptied and when the barium has sunk well below the level of the crater it remains in the crater because of the absence in the crater of secretory and peristaltic activity of the mucularis mucosae. These two factors tend to rid the normal mucosa of any coating of barium but the inert crater has not

FIG. 37.—*Left lateral view of the lesser curve showing formation of a perigastric cavity or accessory pocket. Note the two layers separating air above and barium respect of.*

the power to do so. Indeed the residue of barium is often exceptionally dense since the barium particles tend to settle and silt up the crater

HEALING CHRONIC ULCER—As an ulcer heals changes in its X-ray appearance take place

(1) The oedema of its edge lessens. This makes the ulcer shallower and widens its neck

(2) The ulcer begins to fill up from below

These two changes tend to give the healing ulcer a V shape, the angle of the V widening as healing progresses. Eventually if as a result of treatment the associated gastritis entirely clears up a shallow rounded crater is left. It is at this stage that it is difficult to be certain radiographically whether an ulcer has healed or not. The crater may be no more than a millimetre or so in depth



and any associated spasm of the greater curve disappeared. Unless the ulcer crater be viewed tangentially to the barium filled stomach it may well be missed and an ulcer pronounced to be healed when in fact healing is not complete (Fig. 38).

The above provides a pretty bone of contention between the protagonists of the medical and surgical methods of treatment of peptic ulcer and the search for a shallow ulcer must be very thorough before it is safe to say that the lesion is completely healed.

Direct Sign of Ulcers in Special Sites

PYLORUS—For anatomical reasons pyloric ulcer presents different radiographic features from those elsewhere. The ulcer being more or less enclosed in a muscular ring no mucosal oedema can develop and as a rule no deep crater is visible. If a crater be seen at all in the pyloric canal it is usually small and shallow. In other cases the niche may be in the form of a spicule or a true diverticulum. If seen en face a rosette appearance (*la cocarde*) may be seen from the central sleek and the radiating plicae. More commonly some distortion only of the canal is visible and associated with it some deformity of the duodenal bulb. This distortion is marked if the ulcer crater extends into the duodenum as it not uncommonly does. In some cases there is an actual pylorospasm a condition which makes the demonstration of the ulcer very difficult (Fig. 39).

LUNGS—An ulcer in this rare site is difficult of direct demonstration. It is most likely to be seen in a relief pattern radiogram prone or supine. Its demonstration is largely a matter of chance.

X R H—o



Fig. 38.—Healing lesser curvature ulcer taken at monthly intervals.

and screen examination is necessary to determine the particular position in which the crater can best be seen if at all.

CARDIA—This is another rare site. The ulcer is usually situated just below the orifice and may be visible as a niche. Not uncommonly there is a projection of the barium shadow in this region from a mucosal fold and it is



FIG. 39.—*Two cases of chronic ulceration*

always difficult and may be impossible to differentiate between the two. Again just below the cardia is the commonest site of a gastric diverticulum which may also be mistaken for an ulcer crater.

INDIRECT SIGNS OF GASTRIC ULCER

Gastropasm

This is the commonest indirect X-ray sign of gastric ulcer.

It is either circumscribed or regional. If the ulcer be on the lesser curve the most typical spasm is a localised notch on the greater curve opposite the ulcer. This notch or *incisura* may be shallow or may extend almost to the lesser curve and produce a pure spastic hour glass stomach of the B type (Fig. 40). While usually opposite the ulcer crater it is not invariably so and may occur either above or below it. The latter is the commoner variation.

Sometimes instead of a single notch there may be present a series of notches of varying depth. The deepest is usually at the centre of the group and those on either side gradually diminish in depth (Fig. 41). Again there may be

a series of small indentations of equal width spread along the greater curve. Such *incisuræ* must be distinguished from two other conditions giving a somewhat similar appearance. Thickening of the mucosal rugae in a not too completely filled stomach is the one which most closely simulates it. Indeed, rugal thickening from chronic gastritis is a not uncommon accompaniment of gastric ulcer and both a spastic *incisura* and notching from mucosal thickening



FIG. 40.—Large lesser curve ulcer with spasm & hour glass deformity.
Deformed due to basal bulb from of I ulceration.

may be present together in a case of ulcer of the lesser curve. The notching of the greater curve by increase in the rugae is a very common accompaniment of peptic ulcer anywhere—it represents a reflex mucosal phenomenon and is aptly described by the Germans in the term *Zahnung*. The other cause of indentation of the greater curve—*extrinsic* pressure from a gas filled splenic flexure—produces a coarser and less regular indentation.

In the so called organic hour glass contracture a large amount of the deformity is due to spasm. Indeed in many of the cases of hour glass stomach

in which there are two completely separate loculi, with a long narrow channel of communication, the deformity may be entirely spastic. As a rule, however, these grosser forms of hour glass contracture are partly organic and partly spastic. A feature of these contractures is the sagging of the upper pouch well below the level of the ulcer and communicating canal, due to the obliquity of the contracted muscle fibres.

In contradistinction to this is the X shaped hour glass of scirrhous carcinoma.

In cases of pyloric or juxta pyloric ulceration a regional spasm may occur of the pyloric antrum. It is usually associated with a pylorospasm and appears as a lack of filling of the antrum close to the pylorus. A rather longer spastic contracture of the pyloric antrum is commonly seen in gastritis or ulcer following gastrojejunostomy.

INTRINSIC OR EXTRINSIC GASTROSPASM — Carman held that these two types could be differentiated by administration of belladonna or atropine. His view was that if the spasm be intrinsic exhibition of atropine to full physiological effect would not affect it while it would abolish a gastropasm due to such causes as duodenal ulcer, biliary disease or chronic appendicitis. Hurst denies that atropine has



FIG. 41. Ulcer crater on the lesser curve with associated gastritis and gastropasm.

the selective property. The test has fallen out of use now because of its uncertainty and more particularly because with improved technique of recent years the direct demonstration of the lesion is more certain. In addition the procedure is unpleasant for the patient as the drug has to be pushed to full pharmacological effect. Benzedrine sulphate mg 10-30 is said to be effective in abolishing gastropasm.

Abnormalities in Size, Tone, Peristalsis, and Rate of Emptying

At first sight changes in the above properties of the stomach show a bewildering variety and irregularity. Any attempts to co ordinate them directly with the type of ulcer crater prove unsuccessful. In one case a lesser curve ulcer is associated with hypertonus by hyperperistalsis and rapid emptying and in another the reverse. The same is true of the similar so called secondary signs of duodenal ulcer. In reality they are not strictly signs of ulcer at all. *Hurst* has pointed out that if the above changes be considered relatively to the pyloric function some order emerges from the chaotic variety. He groups ulcers of the stomach as follows:

(1) GASTRIC ULCER WITH NORMAL PYLORIC FUNCTION (ulcus simplex)

(2) GASTRIC ULCER WITH PYLORIC ACHALASIA.—In this the initial opening of the pylorus is later than normal and the periodic relaxations are infrequent and relatively ineffective. Relaxation can be assisted by palpatory pressure and a normal amount of the contrast medium forced into the duodenum. *Hurst* describes pyloric achalasia as a reflex inhibition of relaxation resulting also from a remote abdominal lesion such as an appendicular or a biliary focus of irritation.

(3) GASTRIC ULCER WITH PYLOROSPASM.—In this condition none of the meal can be forced through the pylorus. The condition simulates pyloric obstruction in the early stages of the examination and later relieves to allow the stomach to empty.

(4) GASTRIC ULCER WITH PYLORIC OBSTRUCTION in which the pylorus fails to open normally at all.

In the study of the pyloric function note must be made of any transparent contents already in the stomach when the opaque meal is given. The barium meal usually divides such contents into two portions, the smaller of which passes into the pyloric antrum and is trapped there as in a U tube. The major portion floats up on top of the opaque meal in the gastric fundus. The former lesser moiety must pass out of the pyloric antrum into the duodenum before the pyloric ring and duodenal bulb can be visualised. This state of affairs must be distinguished from the above mentioned pyloric abnormalities and can be noted in the pyloric antrum during a phase of relaxation the horizontal fluid level made by the contact of trapped fluid and opaque medium.

Size and Tone of Stomach in Gastric Ulcer

(1) ULCUS SIMPLEX.—A simple ulcer without change in the pyloric function had no influence in gastric tone. The presence of hypertonus or hypotonus depends on the habitus of the patient and not on the ulcer. In actual practice hypotonia is very commonly present in cases of gastric ulcer—in 90 per cent according to *Aohler*—and hypertonus much less commonly.

This *Hurst* explains by ascribing to the gastric habitus a determining

effect on the site of the ulcer. Thus a pre-existing hypertonus tends to localise a peptic ulcer in the duodenum, while hypotonia tends to the development of the ulcer in the stomach. *Hurst* regards this as an important factor in the localisation of the ulcer, particularly duodenal ulceration. The writer is not convinced that this is true.

(2) ULCER WITH PYLORIC ACHALASIA.—This likewise has no effect on gastric size and tone.

(3) ULCER WITH PYLOROSPASM.—Increase in size and lessened tone result.

(4) ULCER WITH PYLORIC OBSTRUCTION.—The hypotonia is marked and develops into atony and marked gastric dilatation.

Peristalsis in Gastric Ulcer

This again depends largely on the pyloric function and on the patient's habitus.

In simple ulcer, or in one with associated pyloric achalasia, peristalsis is unaffected. In one with pylorospasm peristalsis is increased at first and later diminished. If the pylorus be obstructed, gross initial hyperperistalsis is the rule, the dilated stomach writhing with wide deep peristaltic waves. In a short time after ingestion of the meal this is replaced by aperistalsis and atony.

Rate of Gastric Evacuation in Gastric Ulcer

This will depend on the factors already considered, namely tone, peristalsis, and pyloric function, but it is a very common feature in lesser curve ulcer to find a small six hour residue in the stomach. This should be tested fasting. The residue may be due to hypotonia, to pylorospasm or to pyloric stenosis. In those cases in which it is due to hypotonia the stomach empties freely in the early stage of evacuation, but seems unable to rid itself of the residual pool of barium in its lower pole. The persistence of the residue is postural in cause. If the patient assumes the horizontal posture during the six hour period, complete gastric evacuation occurs in normal time. When the gastric delay in evacuation is due to disturbance of the pyloric function, this will be apparent on screen examination immediately after the meal is taken when the pyloric dysfunction will show itself.

Localised Tenderness on Pressure

This is a sign on which stress used to be laid, but one which has ceased to be of importance since direct demonstration of the ulcer crater became the desideratum. If there be persistent and localised tenderness on pressure over an ulcer crater, such tenderness is obviously an indirect sign of ulcer, but one which is of little importance in view of the visible crater itself. In the absence of a crater or deformity, the sign is so uncertain as to be valueless. It would, however, be of significance if found over a localised area in the lesser curve.

with a corresponding incisura on the greater curve. If a tender point be present, and known to be due to an ulcer, its value is that it indicates an active stage of the ulcerative process. It is commonly held to be due to visceral tension in the ulcerated area produced by the palpating finger.

This indirect sign becomes relatively more important in areas where it is difficult to demonstrate the ulcer crater—e.g. pyloric and gastro-jejunal ulcers—but it is a sign of no great certainty. Its localisation must be meticulous and its interpretation guarded.

Fränkel's Sign, or "Peristaltic Jump"

This sign would be of importance if it could be demonstrated easily. It consists of an interruption of the peristaltic wave on the lesser curve by the ulcerated area. The latter takes no part in the wave, which begins again on the distal side of the lesion. It was shown first by Fränkel in a rapid series of films by superimposition. The sign is of greater importance in early carcinoma, or will be when advances in cineradiographic technique allow it to be easily and accurately demonstrated.

Segmental Rigidity and Straightness of the Lesser Curve

Duvau, Roux, and Beclère lay stress on these as signs of ulcer somewhere in the stomach. Peristaltic sinuosity is absent, according to these authors, for a variable length on either or both sides of a niche on the lesser curve. It is a sign difficult to detect with certainty, and while, if it is seen, it should raise the suspicion of ulcer, by itself it can do no more diagnostically.

CICATRICIAL SIGNS OF GASTRIC ULCER

These are three in number—pyloric stenosis, organic hour glass contracture, and contracture of the gastro-hepatic omentum.

Pyloric Stenosis

Three stages can be made out in chronic pyloric stenosis from the scarring of an ulcer.

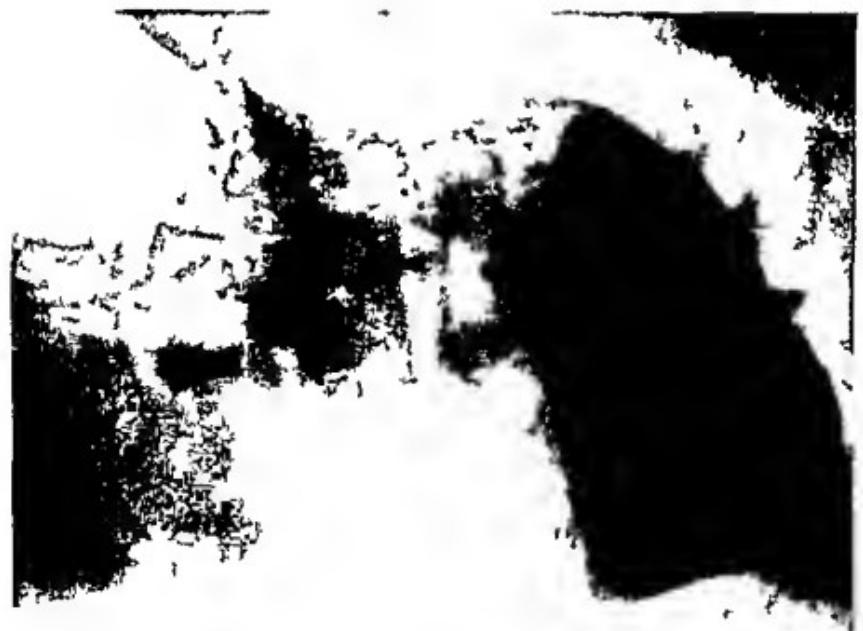
FIRST STAGE COMPENSATED—In this stage the stomach shows little or no dilatation, peristalsis is active but not excessively so, and evacuation takes place slowly but fairly efficiently. In this stage it is usually possible to demonstrate the narrowed pyloric canal. In order to do so, it is essential that the stomach be empty, as retained secretion and food make it impossible to fill the canal with barium.

SECOND STAGE OF FAILING COMPENSATION—Considerable gastric dilatation is present. Initial hyperperistalsis is excessive, and succeeded by atony as the gastric musculature tires.

A pyloric stenosis which has reached a developed second stage presents very characteristic features on barium meal examination.

Fig. 4. Left observation of a bilateral testicular teratoma.

Fig. 5. Testicular obstruction of the left testis due to a large teratoma.



On screen examination in the erect position the first abnormality that strikes the observer is the mode of filling of the stomach. The barium is seen either to slide down the lesser curve to the lower pole or much more commonly to drop in round blobs through transparent fluid contents already in the stomach. Even with careful preparation and withholding of food or liquid for hours before the examination the stomach will be found to contain quite

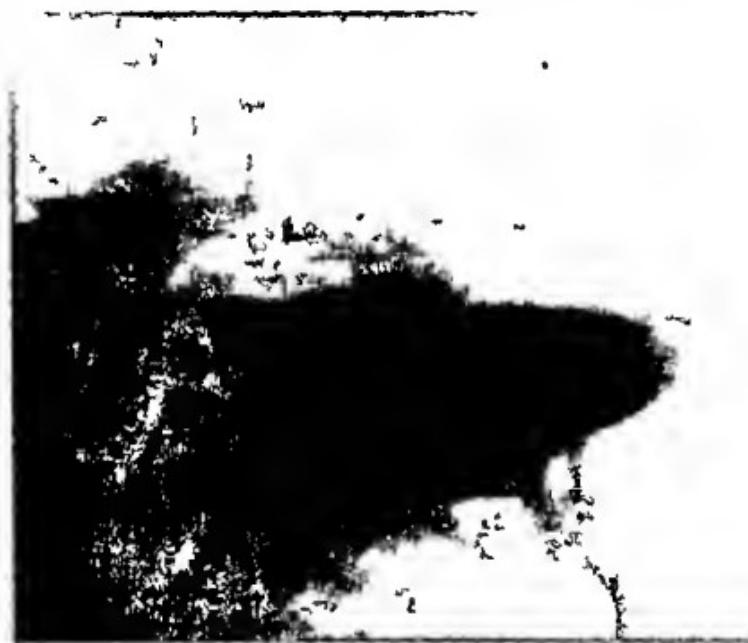


FIG. 44.—Seven hours gastric residue in pyloric obstruction—the wide pool of obstruction.

a large amount of liquid (Fig. 42) chiefly swallowed saliva and resting gastric juice.

As soon as the stomach becomes partly filled vigorous hyperperistalsis sets in the waves being deep and wide. A characteristic of them is that the lesser curve also shows deep peristaltic indentations equal in magnitude to those on the greater curve. This large wave hyperperistalsis is seen only in pyloric obstruction (Fig. 43). The large size is due to the gastric dilatation. In non-obstructive hyperperistalsis the waves are smaller and more numerous.

In this stage of stenosis it is not always possible to demonstrate the pyloric canal itself. If possible at all the prone position is the best in which to show it. In that position a narrow streak of barium may sometimes be seen in the stenosed passage.

FIG. 42.—Pyloric obstruction with marked dilatation and hypertonia. Transparent contents occupy the lumen of the lumen.

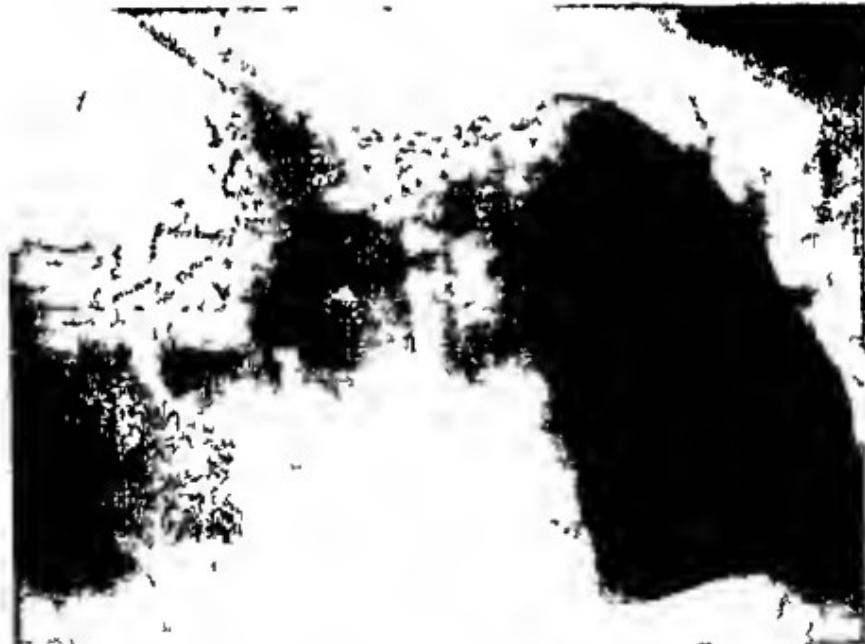


FIG. 43.—Dilatation of the stomach showing dilatation and initial hypertonia. transparent contents occupy the lumen of the stomach.



On screen examination in the erect position the first abnormality that strikes the observer is the mode of filling of the stomach. The barium is seen either to slide down the lesser curve to the lower pole or much more commonly, to drop in round blobs through transparent fluid contents already in the stomach. Even with careful preparation and withholding of food or liquid for hours before the examination the stomach will be found to contain quite



FIG. 44.—Seven hours gastric residue in pyloric obstruction—the wide pool of obstruction.

a large amount of liquid (Fig. 42) chiefly swallowed saliva and resting gastric juice.

As soon as the stomach becomes partly filled vigorous hyperperistalsis sets in the waves being deep and wide. A characteristic of them is that the lesser curve also shows deep peristaltic indentations equal in magnitude to those on the greater curve. This large wave hyperperistalsis is seen only in pyloric obstruction (Fig. 43). The large size is due to the gastric dilatation. In non obstructive hyperperistalsis the waves are smaller and more numerous.

In this stage of stenosis it is not always possible to demonstrate the pyloric canal itself. If possible at all the prone position is the best in which to show it. In that position a narrow streak of barium may sometimes be seen in the stenosed passage.

After a variable but usually short time the gastric hyperperistalsis dies down and hypotonia sets in until the ingestion of a further meal excites vigorous peristalsis again. In the hypotonic stage the stomach will show in the erect position a pool of barium at the lower pole topped by transparent fluid (Fig. 44). It is characteristically wide and shallow as a result of the gastric dilatation. In contradistinction to this the residue in simple non-obstructive hypotonia is deeper, extends less from side to side and more nearly approximates to a semicircular shape.

The final point in the diagnosis of pyloric stenosis is the amount of the residue and its duration. So far as the duration is concerned a six or seven hour residue may result from simple ptosis and hypotonic pylorospasm or stenosis. The size and shape of the residue may give a clue to the type. If however there is a gastric residue at the twenty fourth hour the condition is almost certainly one of organic stenosis. A twenty four residue is virtually pathognomonic of considerable organic narrowing of the pylorus.

In milder degrees where there is a residue only to six to eight hours and doubt arises as to whether the delay is due to gastroparesis the postural test may be applied by instructing the patient to remain recumbent after taking the meal. This will abolish the delay due to ptosis but will have little effect on that due to pyloric stenosis.

THIRD STAGE COMPLETE ATONY of the stomach is approached. Initial peristalsis is not a marked feature while dilatation is. The stenosis is so marked as to cause almost complete obstruction and the stomach is emptied chiefly by vomiting. Little can pass via the pylorus.

In this stage there may be little or no twenty four hour gastric residue, as all the barium may have been vomited and enquiry should be made as to this factor in cases of gross pyloric stenosis.

Differential Diagnosis—From the above it will be seen that pyloric stenosis or obstruction whatever its cause gives a typical clear-cut radiological picture in its various stages. Its diagnosis is simple but the determination of the precise cause is often difficult and may be impossible.

There are however certain points which may help in the differential diagnosis between post ulcerative stenosis and the other types.

(1) **PYLOROSPASM**—This although not a stenosis may simulate it at first view. It can arise from many causes such as peptic ulcer anywhere in the stomach or duodenum, cholecystitis, pancreatic, renal and appendicular lesions. Stasis in the stomach may result but it is usually only an initial delay in emptying. The hyperperistalsis, dilatation and atony of the type described above are absent and the condition is inconstant. A deciding point lies in the demonstration at some stage in the examination of a normal pyloric canal. When the pylorospasm is associated with a pyloric or juxta pyloric inflammatory lesion it will usually be impossible at first sight to apportion the amount of the obstruction due to the spasm and

cedema, and that due to permanent scarring. When there are clinical indications that the lesion is in the pylorus, it is worth while applying the therapeutic test, by placing the patient under a strict medical regime for some weeks. What was previously a twenty four hour stasis may be reduced to a seven- to ten hour stasis, or the size of the twenty four hour residue may be diminished. More accurate information as to the need for operation is then available.

(2) STENOSIS AND OBSTRUCTION FROM TUMOURS.—Carcinoma is nearly always the tumour responsible. It may produce general gastric signs identical with those of simple stenosis. The dilatation is not usually so great, but additional signs are often present.

(a) The so called amputation of the pylorus. The pylorus and prepyloric region are not visible at first. This is followed by filling of

(b) The stenosed passage which may be narrow, tortuous, and constant in its form.

(3) HYPERSTROPHIC STENOSIS OF THE PYLORUS OF ADULTS.—The characteristics of this rare condition are described later.

Although the differential diagnosis may be difficult, an attempt to find the precise cause should always be made, for purposes of treatment. A carcinoma is an urgency, while even if gastrojejunostomy is contemplated in simple obstruction some weeks of strict medical treatment is an obviously desirable preliminary to operation.

Hour-glass Contracture of the Stomach

Used in its widest sense—that of a biloculation of the stomach—the term includes a variety of conditions. The following list includes the majority of these, some require no further mention and others some detailed description.

(1) WITHOUT ORGANIC STENOSIS

(a) *Physiological*, the result of marked hypotonia. The appearance of this is characteristic, a gentle narrowing in the pars media. Occasionally, in women with very thin waists, this narrowing may be quite abrupt in the greater curve.

(b) *Physiological Cascade Stomach*

(c) Due to extrinsic pressure from tumours of the spleen, pancreas, left kidney, etc., and particularly from a gas filled colon. In the last named type, particular note should be made of the gas filled colon rising in front of the liver. This produces the most marked degree of this type of biloculation, and borders on the state described under chronic intermittent volvulus of the stomach.

They all show distinguishing characteristics their variability their smooth contours and an intact gastric mucosa.

(d) *Pure Spastic Biloculation*—This has already been described under the signs of gastric ulcer. It may also occur as a reflex spasm from biliary, appendicular and other remote abdominal lesions and is said to occur in chronic tobacco poisoning.



FIG. 45 Lesser curve hour-glass contracture

(2) WITH ORGANIC STENOSIS

Simple Cicatrical Hour-glass Contracture—The forms which simple organic hour glass contracture may take are many and varied depending on the precise degree and site of the scarring but most of these present certain common characteristics by which they can be distinguished from the carcinomatous variety (Figs. 45 and 46).

(a) The contracture is nearly always at the expense of the greater curve and the isthmus is at the lesser curve—this gives the B shape so often referred to.

(b) The lower pole of the upper loculus is almost invariably considerably below the level of the isthmus.

(c) The isthmus is usually

in the middle third of the stomach and its point of origin frequently coincides with an active ulcer on the lesser curve. In other cases it may be a little below an active ulcer having been caused by a healed ulcer below the active one (Fig. 47). The calibre of the stenosis varies greatly in different cases and it is important to note the width seen in the radiograms and also to observe the rate at which the meal passes from the upper to the lower loculus. In severe cases the lower loculus may not fill for half an hour and there may occur stasis in the upper loculus up to twenty four hours.

Delay of this order usually means considerable cicatrical stenosis a lesser degree can however be produced by spasm superadded on a biloeculation with quite a wide isthmus. This may be tested by subsequent examination after a few weeks of rigorous medical treatment. The latter may relax the spasm and reveal the true degree of the organic narrowing. Exhibition of benzedrine sulphate may help in the differentiations. The length of the isthmus may be from 1 to 3 inches.

Stasis may occur in the lower oesophagus depending on the pyloric function—either from pylorospasm or organic stenosis there. It is of importance to estimate the mobility of the stenosed channel since adhesions to the liver or pancreas are common and add to the difficulty of a partial gastrectomy.

The observer on meeting with a case of organic hour glass contracture should not rest content with its demonstration but should take all possible steps to show whether there is an active ulcer associated with it either on the lesser curve pylorus or duodenum since the presence of an active lesion may influence the choice between medical and surgical measures.

Malignant Organic Hour glass Contracture—This is described under the section on carcinoma of the stomach.

Gastric Adhesions

Gastric adhesions may give radiological evidence of their existence by lessened mobility or displacement of the stomach or by distortion of its contour (Figs 48 and 49) but many of the simpler adhesions cause no visible change.

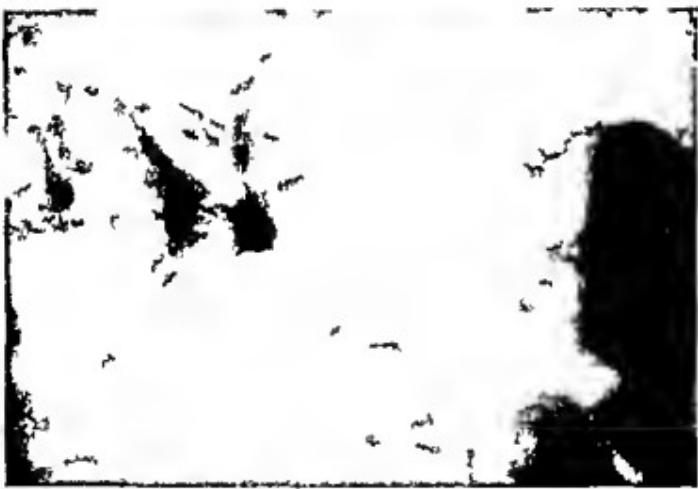


FIG. 46.—Lesser curve ulcer at 11. hour glass contracture

Fig. 48. In lesser two lower
incisors, resection of half root to
be rated. The full section imposed on
lower



Fig. 47. Lesser two lower
incisors sectioned to be rated.
For this reason, the
crown is removed.



In general, it is wise to refrain from making such a diagnosis unless it is quite certain that there is no more serious explanation of the abnormal



FIG. 49.—Lesser curve ulcer (→) hour glass contracture and deforming adhesions of the gastro hepatic omentum

appearance, such as ulcer of the lesser curve with contracture of the gastro hepatic omentum or gastric neoplasm. It is said that extensive deforming adhesions can simulate the latter

CHAPTER VII

OTHER INFLAMMATORY LESIONS OF THE STOMACH

GASTRITIS

IT WILL be seen from Chapter II that in attempting to assess the pathological significance of alteration in the form of the gastric rugae those changes due to physiological and other factors must be discounted. This applies particularly in cases of gastritis in which the gastric rugae are said to be thickened, rigid and tortuous. It is usually a matter of the greatest difficulty to say whether a given degree of rugosity of the gastric mucosa is physiological or pathological particularly when the folds are usually seen only with the stomach relatively empty and in the present state of our knowledge of the radiological appearance it is in most cases wise to refrain from such a diagnosis on a reflex pattern of the semi-collapsed stomach alone.

If however this apparent thickening and tortuosity are accompanied by a depression of the greater curve when the stomach is filled with a



Fig. 8. Duodenal ulcer and marks of associated gastritis.

barium cream containing no food the diagnosis of gastritis receives more support. According to *Kadrika's* observations the rugae should then be small and should cause no indentation of the greater curve. This of course is upheld by the appearance in the normal stomach in the vast majority of examinations

It should be borne in mind that the commonest cause of erosion of the greater curve is a *peptic ulcer* (Figs. 50 and 51) and only after the most rigorous search has failed to disclose an ulcer crater should the milder lesion gastritis be diagnosed.

Perianastomotic gastritis is a common sequel of gastrojejunostomy in those cases in which the acid curve remains high and the mucosal pattern may give some indication of this. Again the same difficulty arises since the gastric mucosal pattern is frequently rather coarse in the normally functioning gastroenterostomy. Other signs are therefore necessary, such as a stomal ulcer or stenosis, jejunitis, tenderness over the stoma and the clinical symptom complex before such a case can safely be labelled as one of gastritis.



FIG. 51.—Healing ulcer with associated gastritis and radiating mucosal corona. History of recent haematemesis.

ATROPHIC GASTRITIS

G. E. Elde has given account of the appearances of the gastric mucosa in simple achylia gastrica and Addison's anaemia.

The majority of the former cases showed no change from the normal. In the few cases in which the usual hypertonus was replaced by atony a narrowing of the folds was noted and in one or two cases a thickening.

In the atrophic gastritis of Addison's anaemia the mucous relief pattern was normal in most cases and in a few the rugae were coarsened.

No reliance can therefore be placed on the relief pattern in atrophic gastritis. This may be deduced *a priori* from the pathological change. The atrophy involves principally the epithelial layer, and the muscularis mucosae and vessels of the submucosa which constitute the autoplastic mechanism are unaffected. Probably such variable abnormalities which have been noted in these cases are not produced by the atrophy at all but by some other incidental factor.

PLASTIC LINITIS

(*Syn. cirrhosis of the stomach, fibromatosis of the stomach, leather bottle stomach*)

History—First named cirrhosis of the stomach by *Andral* in 1845 it was described accurately by *Brinton* in 1859. It has been studied in detail by *Alexis Thomson*.

Aetiology—There has been considerable difference of opinion regarding this. Some cases presenting the clinical radiological and naked-eye pathological features of linitis plastica have turned out to be diffuse scirrhouous carcinoma and syphilis can produce a similar macroscopic appearance. Excluding these there remains a group which according to *Thomson* are due to infection spreading from an ulcer. It is a disease of adult life.

Pathology—The condition consists of a diffuse spreading fibrosis of the submucosa starting usually at the pyloric region. The muscularis is involved in the fibrotic change to a less extent and the gastric capacity is diminished.

Radiological Features—The diminished gastric capacity is immediately evident on screen examination. The diminution takes place particularly at the pyloric end of the stomach and is less marked as the fundus is reached. The stomach is relatively aperistaltic. The pyloric canal involved in the fibrosis remains widely patent and the meal pours rapidly into the small intestine. The appearance of the mucosal pattern is variable. If the mucous membrane is relatively uninvolved in the fibrotic process the rugae are rendered more prominent by the contraction of the gastric lumen. If the mucosa is atrophic the rugae gradually disappear.

As in any case of marked diminution in the gastric capacity compensatory oesophageal dilatation may take place particularly if the pylorus be not gaping.

The contour of the stomach shows a mild irregularity only depending on the distribution of the fibrosis.

It will be seen that it is quite impossible to distinguish radiologically between the carcinomatous syphilitic and infective types of linitis plastica. Even where the Wassermann reaction has excluded the specific form the carcinomatous tissue remains in such doubt as to make laparotomy advisable in all cases where there is hope of a successful gastrectomy.

SYPHILIS OF THE STOMACH

Incidence—Tertiary syphilitic lesions of the stomach congenital and acquired are extremely rare occurrences in England. Only one authentic case (*McAree's*) has been published in this country. It is reputed to be common in China and Russia. *Easterbrook* gives an incidence in America of 0.3 per cent of 2,500 cases of gastric ulcer operated on at the Mayo Clinic.

Pathology—The disease begins as an infiltration in the submucous tissue and may be diffuse or localised. Ulceration and contracture soon supervene. The ulcers are frequently multiple and associated with hyperplasia of the gastric wall. The pyloric antrum is the commonest site of the condition.

Radiological Features—In a condition with such protean morbid anatomy, the radiographic picture is bound to be varied. *Lellald* has described the following types:

(1) **GENERALISED INFILTRATION**, producing a stomach markedly diminished in size with rapid emptying and compensatory oesophagogastritis. Peristalsis is diminished or absent. The condition closely simulates *antritis plastica* and generalised scirrhoue carcinoma.

(2) **THE DUMB BELL DEFORMITY**, resulting from fairly symmetrical infiltration and contracture of the pars media. A large annular scirrhoue carcinoma produces the same deformity and this type is usually diagnosed as such.

(3) **LOCALISED AREAS OF INFILTRATION AND ULCERATION** in the stomach. This type simulates a fungous carcinoma.

(4) **LOCALISED PYLORIC AND PREPYLORIC INFILTRATION**, which tends early to produce stenosis. It produces a filling defect very similar to that of a scirrhoue carcinoma.

The differential diagnosis between gastric syphilis and the other lesions which it may simulate cannot be made on the radiographic evidence. Due attention must be paid to signs of syphilis congenital or acquired elsewhere and to the Wassermann reaction. A final proof is the result of vigorous antisyphilitic treatment. In a number of cases reported by *Lellald restitutio ad integrum* has radiographically speaking taken place after some months of treatment. This obviously is too lengthy a procedure to adopt as a diagnostic measure with a carcinoma as the probable alternative diagnosis unless the lesion is so advanced as to be inoperable if it is malignant.

TUBERCULOSIS OF THE STOMACH

This is always secondary to tuberculosis elsewhere most often pulmonary next in frequency intestinal. It is usually a terminal stage in the course of a tuberculous illness and as such rarely reaches an X-ray department. *Broders* has collected 306 recorded cases and has grouped them into two types:

(1) **Hypertrophic** (20 per cent)—This type usually occurs in the pyloric region and produces large filling defects very similar to those of an encephaloid carcinoma.

(2) Ulcerative (80 per cent)—The ulcer is usually on the lesser curve. There are no distinguishing radiological features between it and simple ulcer except that it tends to be larger.

Reliance must thus be placed on the presence of tuberculosis elsewhere in the body in the differential diagnosis of gastric tuberculosis.

ACTINOMYCOSIS OF THE STOMACH

This is of extreme rarity. Schinz has recorded a case in which the gastric lumen was considerably narrowed and irregular in contour. It simulated a rather ragged scirrhus carcinoma. Behring describes a case of actinomycosis of the pylorus and adjacent duodenum which gave a radiographic picture of pyloric obstruction. He reviews the literature and notes eight cases of which only three were primary in the stomach and one in the duodenum. In one of the gastric cases the radiographic diagnosis was lesser curve ulcer and in the other two carcinoma.

On considering the macroscopic pathology of the disease one would expect to find irregular filling defects, rigidity of the gastric wall and diminution of the gastric capacity all of which would render a radiographic diagnosis of carcinoma inevitable.

GASTRIC FISTULÆ

External Fistulæ

These may result from trauma—wounds or operations—or from pathological lesions such as subacute perforation of a gastric ulcer.

They are best demonstrated radiographically by an injection of an opaque cream or lipiodol into the opening. If the track be tortuous stereoscopy is of help in demonstrating its ramifications. In order to prevent the contrast medium from leaking away externally the sinus should be sealed with adhesive plaster immediately after the injection. In other cases it may be necessary to keep up pressure from the injecting syringe in order to ensure that the track is filled when the radiogram is taken. A rubber tipped urethral syringe is an advantage here.

By these means the track of the fistula can as a rule be traced down to the viscus with which it communicates. In these fistulae a satisfactory view may sometimes be obtained by taking a tangential view after filling the stomach with barium cream and the fistula from the outer opening if necessary.

Internal Fistulæ

These may be the result of trauma (usually operative) or disease. The colon is the other viscus most commonly involved rarely the gall bladder and other viscera.

GASTRO-COLIC FISTULA is usually the result of carcinoma most often of the stomach and much less frequently of the colon. Less commonly it is the result of simple ulcer tuberculosis of the colon or following gastro-jejunostomy.

GASTRO-JEJUNO-COLIC FISTULA—While gastro-jejunostomy may be the cause of gastro colic fistula the end result is more commonly a jejunocolic

ila from the perforation of a jejunal ulcer into the transverse colon. This with the already existing gastro jejunostomy forms a gastro jejunum colic fistula.

Although gastro colic and gastro jejunum colic fistulae usually give a history that is almost diagnostic the diagnosis is made clear by X-ray examination. Either a barium meal or a barium enema may demonstrate the lesion but the latter method is quicker and much more certain. Sometimes the enema shows the state of affairs clearly after the barium meal has failed to do so.

The barium enema appearances are quite characteristic. The colon fills normally with the enema as far as the transverse colon. Then depending on the type the enema floods the jejunum and stomach or the stomach alone. As the patient is lying supine while the enema is being run in the gastric fundus fills up in a way that leaves no doubt as to the nature of the condition. The presence or absence of jejunal flooding determines whether the fistula is gastro jejunum colic or gastro colic.

It is of importance to be able to indicate the cause of the fistula. The detection of a colonic or a gastric filling defect indicates carcinoma as a cause. Here the barium meal is of value so far as the stomach is concerned. The history of gastro jejunostomy and the jejunal flooding indicate the cause in the post-operative type.

The barium meal appearances are also usually quite characteristic. As the stomach fills the barium pours out into the colon or jejunum and thence colon. Bearing in mind the fact that the actual fistulous connection in a gastro jejunum colic fistula may not be visible and that the jejunum may fill very quickly in the normal it is evident that with a meal examination one must look for an immediate filling of the transverse colon as a proof of the presence of a fistula and in this connection it should be remembered that an opaque meal may reach the transverse colon *per via naturales* in the space of an hour or less. Stress must therefore be laid on the *immediate* colonic filling. This does not always happen. In a case observed by the writer the colonic filling was delayed for an hour. It was not until a barium enema was given that the presence of a gastro jejunum colic fistula was conclusively proved. Barium in the stomach after the administration of a barium enema can mean nothing else than a fistulous track between colon and stomach.

CHOLECYSTO GASTRIC FISTULA—The only other internal gastric fistula deserving of notice is the cholecysto gastric. It results from the ulceration of a gall stone through the adherent walls of the two viscera in question or from perforation of a gastric ulcer simple or malignant. Barium emulsion readily passes from the stomach through the fistula into the gall bladder and thence may pass into the bile ducts. If the bile ducts are outlined the nature of the condition is clearly evident. If however only the gall bladder is filled it might be mistaken for a duodenal diverticulum of the acquired type. A lateral view serves to distinguish between the two. The gall bladder lies anteriorly in the abdomen while a duodenal diverticulum lies on the posterior abdominal wall.

CHAPTER VIII

NEOPLASMS OF THE STOMACH

BENIGN TUMOURS OF THE STOMACH

Types—These are all exceedingly rare Pathologically they fall into three groups—connective tissue tumours glandular tumours and cysts

CONNECTIVE TISSUE TUMOURS—*Fibromata* may be either polypoid or intramural more commonly the former in the pyloric region. *Myomata* and *fibro myomata* form the commonest type in this group. Upwards of sixty cases have been reported. They may be pedunculated either subserous or submucous or intramural. *Angiomata* and *lipomata* may also occur the latter tending to form large intragastric pedunculated tumours.

GLANDULAR TUMOURS—Under this heading are the solitary and the multiple pedunculated adenomata. The *solitary adenomata* form the commonest type of gastric polypi occur usually in the pyloric region and may reach the size of an apple.

The *multiple adenomata* (*syn* multiple mucous polypi gastric polyposis) are spread uniformly over the gastric mucosa and rarely reach a larger size than cherries. They are generally found in conjunction with chronic gastritis.

Cysts—These are rare and result from injury degeneration of tumours implantation of hydatid^a or retention cysts in chronic gastritis.

The hydatid cysts may reach large dimensions.

Radiographic Appearances—It is unlikely that a subserous pedunculated tumour could be demonstrated satisfactorily in a radiogram. The intra-gastric polypoid tumours are on the other hand readily demonstrable with careful technique.

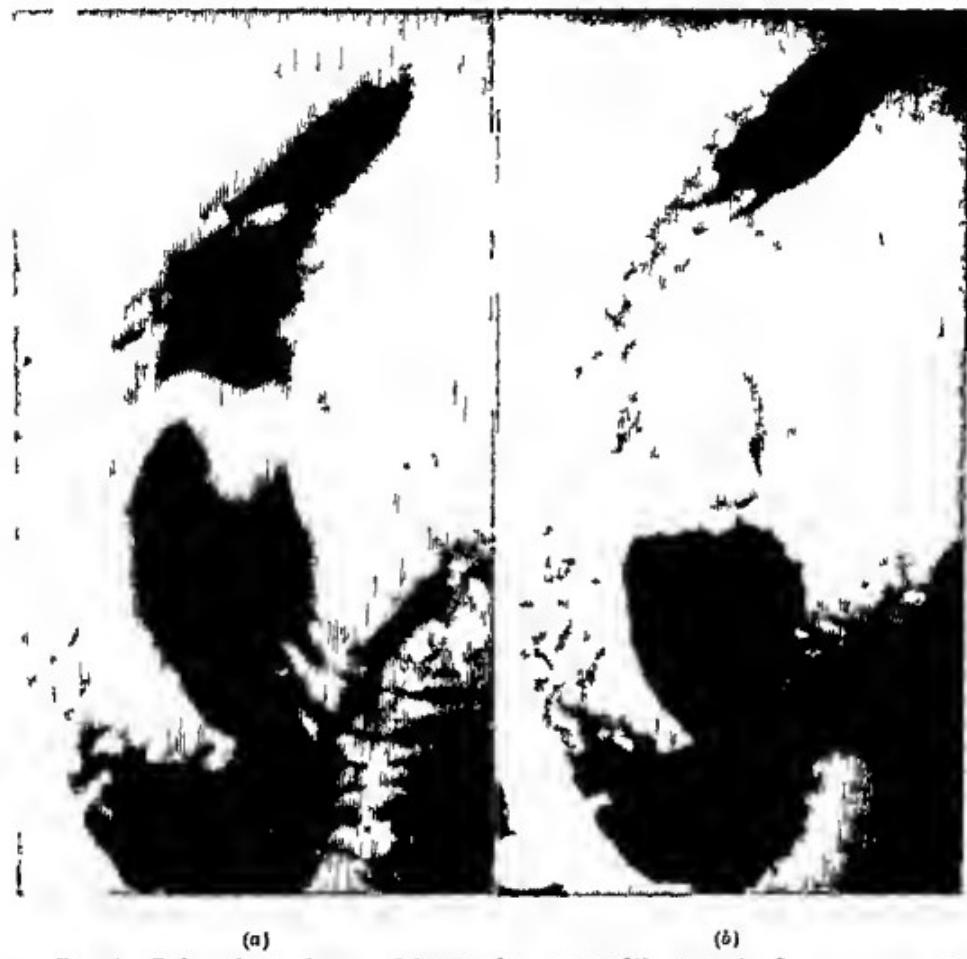
If the tumour be single and small it will be completely obliterated by filling the stomach with an opaque cream. Only by employing the mucosal pattern technique can this type be rendered visible.

If it be single and large it will show in a mucosal relief picture and usually produces a filling defect in the filled stomach. This filling defect tends to be round and mobile.

Multiple polypi produce characteristic filling defects—numerous small rounded gaps in the barium shadow scattered throughout the stomach. If these are not visible in the filled lower pole of the stomach gentle pressure partly to empty the lower pole of barium will bring them into view.

The *intragastric benign tumours* can be shown with great clarity by air

insufflation of the stomach especially if this be combined with previous administration of colloidal barium or diagnothorine to outline the mucosa. The round marble shadows of the polypi in gastric polyposis show clear outlines,



(a)

(b)

FIG. 52.—Pedunculated adenoma of the juxta pyloric region of the stomach. On screen examination the tumour gives rise to a rounded mobile filling-defect and could be dislodged through the pylorus into the duodenum and back again. (a) Shows the tumour in the pyloric antrum and (b) in the duodenum.

in marked contrast to the disorganized irregularity of outline of an intragastric encephaloid carcinoma.

A *juxta pyloric polypoid tumour* may press through the pylorus and cause a rounded mobile filling-defect in the bulb (Fig. 52). A further stage of the same process is a *gastro duodenal intussusception*.

CARCINOMA OF THE STOMACH

The stomach is the commonest site in the body for carcinoma to occur. It is a disease of distressing frequency and the insidious nature of its onset increases the importance of any method of investigation that will lead to earlier recognition of the condition. Radical treatment is feasible only in the earlier stage of the disease, and the earliest stages are quite latent clinically. Radiology affords probably the most reliable method of demonstrating carcinoma of the stomach. In the advanced case the radiographic picture is virtually conclusive.

In the early stages the X-ray method is not quite so conclusive as in the later but still it affords the most accurate method at our disposal for the early diagnosis of gastric carcinoma and by the time such a lesion has begun to give any clinical symptoms it is demonstrable by careful X-ray examination.

Aetiology

AGE—Carcinoma of the stomach may be met with at any age but is commonest between 40 and 60.

SEX—Men are affected more commonly than women in a proportion of about 3 to 1.

PREVIOUS SIMPLE GASTRIC ULCER—Much controversy has ranged round this question but such authorities as *C. H. Mayo*, *Moyruhan Sherren* and *Pauchet* hold that old gastric ulcer active or healed is a definite aetiological factor.

Pathology

Primary carcinoma of the stomach may be composed of either spheroidal or columnar cells. Either type may undergo colloid degeneration. Depending on the amount of stroma present the growth is described as 'scirrhous', or 'medullary', 'encephaloid' or 'fungous'.

The spheroidal celled type is twice as common as the columnar and is the usual type of malignant ulcer.

The columnar type is commonest in the pyloric region frequently in the form of a fungoid growth.

Either type may infiltrate the whole organ giving rise to one form of 'leather bottle' stomach. According to *Sherren* the spheroidal celled variety causes a diminution in the size of the leather bottle stomach while in the columnar celled variety the gastric lumen is not diminished.

Site

In 90 per cent the growth is in the pyloric half of the stomach.

It is located on the lesser curve in about 75 per cent and then in descending order of frequency on the posterior wall the pylorus, the greater curve and the cardia.

This distribution is in agreement with the view that gastric ulcer is a predisposing factor, being very similar to the distribution of the latter.

Cancer of the stomach commences in the deeper layers of the mucosa, and tends to spread widely in the submucous layer. The induration marks the limit of the infiltration of the mucosa but the submucous infiltration may extend for several centimetres beyond. This is of importance in estimating the operability of a growth from the X-ray appearances.

Radiographic Classification

From a radiographic point of view carcinomata of the stomach fall into the following categories:

*Scirrhou*s Localised

Diffuse

Encephaloid

or *Fungous*

Malignant Ulcer

Localised Scirrhous Carcinoma

By the term "localised" is meant a growth affecting portion of the stomach only, in contradistinction to the diffuse type which causes leather bottle stomach. The characteristic X-ray feature of this type is a contracture of the lumen, causing one kind of filling defect.

The filling defect of this type of growth may assume a varied form, depending on the site and extent of the growth. It may involve either curve alone, or both. The narrowing of the lumen may be slight in extent or extreme. It may involve a comparatively short segment of the gastric lumen, or a large portion. The transition from healthy to infiltrated stomach may be gradual or abrupt, so far as the lumen is concerned. As a rule an abrupt stepping back of the barium shadow occurs at this point. A common type of filling defect is the *napkin ring* defect as though a napkin ring were constricting the gastric lumen (Fig. 53). As would be expected, the closer to the pylorus, the narrower the constriction, and those at or close to the pylorus commonly cause obstruction.

Although these defects are so varied in shape, they present certain common features:

(1) They remain constant in shape. Their particular configuration must remain essentially unchanged in a series of radiograms, allowing for slight variations due to the degree of gastric filling.

(2) They are aperistaltic. The peristaltic waves can frequently be traced down to the upper limit of the filling defect, there to disappear.

(3) They display a lessened flexibility when tested by radioscopic palpation.

(4) In contradistinction to the *encephaloid* type these scirrhouous filling defects do not typically present any spiky or jagged outline

(o) A palpable thickening or mass may be present

In the majority of these cases there is no doubt as to the nature of the condition but very early cases may show no conclusive feature and doubt may arise in some of the pyloric growths

In the very early malignant infiltrations the only sign may be the *peristaltic jump* described by *Fraenkel* and then only if the infiltration be on the lesser



FIG. 53. Annular scirrhous carcinoma of the pyloric antrum producing the napkin ring deformity.

or greater curve. If on the posterior wall it would be undetectable radiologically in the very early stages. If on the greater curve it would be more obvious because of the interference with peristalsis.

The mucosal relief pattern is considerably altered by a scirrhouous infiltration the normal ruga stopping short at the edge of the lesion.

Definite changes in the pyloric function take place in scirrhouous carcinoma of the stomach. If the growth be not causing mechanical obstruction the pylorus tends to be widely patent—the gaping pylorus of cancer. In a

certain small percentage of cases this is due to an infiltration of the pyloric canal transforming it into an open rigid tube. Usually however such infiltration causes stenosis and the commoner type of gaping pylorus is functional and associated with the achylia which is the rule in carcinoma of the stomach in any situation.

Commonly the contrast meal is seen to pour in a steady stream through a rigid gastric lumen into the duodenum. The lack of peristaltic activity in extensive scirrhouss growth in no way alters this rapid transit. Indeed



FIG. 54.—Carcinoma of the pars medialis producing a V-shaped hour glass contracture.

more extensive the infiltration the more marked is this feature reaching maximum in the leather bottle stomach.

CARCINOMATOUS HOUR GLASS STOMACH—This appearance results when scirrhouss carcinoma involves the pars medialis in an annular fashion. Characteristically the hour glass is V shaped in contradistinction to the B hour glass simple ulceration (Fig. 54). In the latter the contracture is solely at the expense of the greater curve. In the V carcinomatous type both curves are involved in the contracture the lesser curve to a less degree than the greater. In this type of hour glass the stenosed communicating channel is usually visible in its entire and little or no overlapping of the upper loculins occurs. The isthmus being a filling defect shows the characteristics above described.

Secondary orophageal dilatation is not uncommon in cases of scirrhou-

carcinoma of the stomach where considerable diminution of the gastric lumen has taken place. This dilatation is determined by the curtailed gastric capacity and not on gross obstruction to the gastric efflux.

SCIRROUS CARCINOMA OF THE PYLORIC REGION—In this site the growth usually assumes an annular form and early causes obstruction (Fig. 30). Considerable difficulty may be experienced in differentiating such a lesion from simple cicatricial stenosis or the hypertrophic pyloric stenosis of adults. If the



FIG. 30.—示例性环状坚硬癌的胃部。

obstruction be marked it may be next to impossible to obtain a satisfactory view of the stenosed canal and one may have to be content with the demonstration of organic pyloric obstruction. Careful preliminary preparation directed to ensuring that the stomach is quite empty prior to taking the opaque meal is of importance. If the stomach already contains transparent secretion the demonstration of the stenosed passage is rendered much more difficult. In carcinoma the stenosed passage is as a rule longer and more irregular than in simple stenosis. The differential diagnosis between it and hypertrophic stenosis of adults is discussed in the section on the latter condition.

Diffuse Scirrrous Carcinoma

This gives rise to one form of leather bottle stomach or *linitis plastica*. The striking feature is the diminution in the size of the stomach. It presents

an appearance similar to an exaggerated hypertonus tapering rapidly from the fundus to the pylorus. The stomach is more or less horizontally disposed aperistaltic in the main and rapidly emptying. Its contours will as a rule show mild irregularities and these persist in succeeding radiograms. In other words there is a carcinomatous filling defect present but so extensive as to involve virtually the entire gastric contour (Fig. 56). In these cases again the diminished capacity commonly results in aophageal dilatation a point which



Fig. 6. Scirrhous carcinoma of stomach—leather bottle type.

distinguishes them from total gastropasm (Fig. 57). In gastropasm the contour is more regular and gastric evacuation less rapid.

Carcinomatous limitis plastica shows a lessened flexibility to radioscopic palpation and a tendency to fixation in its position just as does the localized scirrhus lesion.

The simple and aphilitic forms of generalized limitis plastica are identical in their radiographic appearances to those described above and cannot be differentiated radiologically from the malignant type.

Medullary, Encephaloid or Fungous Carcinoma

In this type of neoplasm the filling defect the cardinal X-ray diagnostic feature assumes a different type from that of the scirrhus growth. Consideration of the macroscopic morbid anatomy will indicate the difference. In the

fungous type there is in addition to the mucous and submucous infiltration the formation of irregular tumour masses which project into the gastric lumen. Again ulceration may take place in these tumour masses further to complicate the picture. In addition therefore to the irregularity caused by the infiltration



FIG. 7. Diffuse scirrhous carcinoma of the stomach or malignant rather hotch stomach

tion of the gastric wall similar to but more irregular than that of a scirrhus infiltration there will be seen gaps in the barium shadow due to the projection of the tumour masses into the lumen of the stomach. These added defects are notaptly called finger print defects as they are often rounded or oval and discrete not unlike finger print impressions (Figs. 58 and 59). The true

Fig. 53.—Gastric plateau (curettes) of stomach.

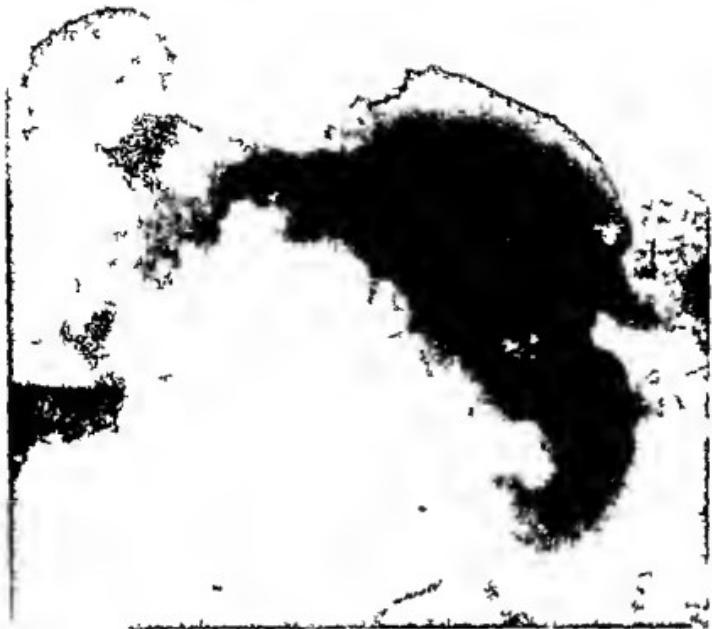


Fig. 54.—Involvement of stomach.





FIG. 60.—Finger-holed carcinoma of the pars media showing the relief pattern.

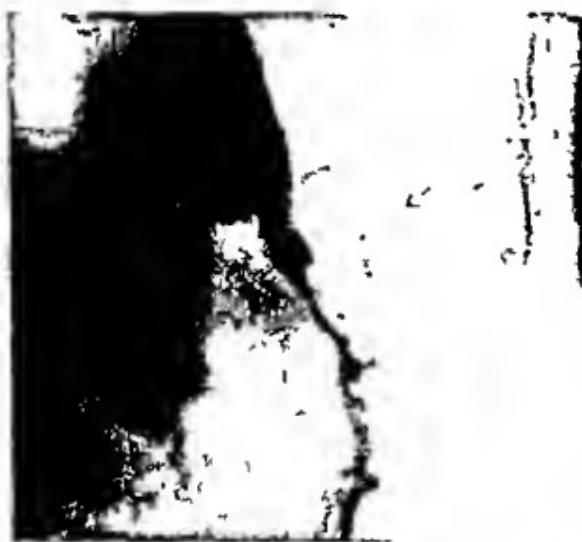


FIG. 61.—Carcinoma of the lower end of the oesophagus involving the cardia. The shadow of the tumour projects into the fundal gas bubble (→).

finger print appearance does not always obtain. In many cases there is merely a large irregular gap in the barium shadow, often with spiky, jagged edges. These fungous filling-defects should be reasonably constant in a series of radiograms, allowing for variation in the amount of opaque cream in the stomach. Those on the contour of the gastric shadow show least change; those inside the gastric contour, due to tumour masses on the anterior or posterior wall may vary considerably according to how much the stomach is distended with the opaque cream. The other radiographic signs, namely the focal aperistalsis, the rapid emptying the gaping pylorus, the lessened flexibility and mobility of the gastric wall, are all apparent in this type as in the scirrhous. The presence of a palpable epigastric mass is more common in this type than in a scirrhous but it is a late feature in both. The oesophageal dilatation and X-hour glass do not typically occur.

The non-oval relief pattern in fungous carcinoma shows a marked and abrupt alteration of the regular pattern into a completely irregular one in the zone involved by the tumour. This destruction

of the normal configuration is more marked than in the scirrhous type (Fig. 60)

Fungous Carcinoma in Special Sites

(1) ANTERIOR OR POSTERIOR WALL.—An early papillomatous growth on the anterior or posterior wall may easily be rendered invisible by too complete filling of the stomach with barium cream. It is important therefore to study the stomach when it contains a small amount of barium only when there is more chance of such small growths being visible in the mucosal relief pattern.

(2) FUNDUS.—Carcinoma of the fundus is usually of the encephaloid type



FIG. 6.—Fungous carcinoma of the posterior wall in an I-beam curve. Extent of the tumor mass is well above the barium.

and produces a filling-defect similar to elsewhere. It is best demonstrated in the supine position.

The majority of growths which involve the cardia are primarily oesophageal and have spread to the stomach round the cardia. Obstruction there is the rule and radiographically a narrowed tortuous track is seen.

Picchio has enumerated the signs of a fundal neoplasm as follows (Fig. 61).

The gas bubble may show the tumour in relief contour. Again the dia phragm outlined by lung above and gas in the fundus below may be unduly thick. The tumour adds its quota to the thickness of this shadow.



(a)



(b)



(c)

The filling of the fundus by a barium cream may be abnormal as the cream pours from the cardia it may trickle irregularly over the tumour mass

The mucosal pattern is interrupted by the tumour mass

Finally the filled fundus shows a filling defect

(3) PYLORIC ANTRUM.—Here obstruction frequently supervenes but the cause is more readily demonstrated radiographically than in the scirrhouous type the jagged irregularity of the stenosed passage as a rule makes the diagnosis easy (Figs. 62 and 63)

Carcinomatous Ulcer

Carcinoma developing in the edge of a simple peptic ulcer cannot be detected in the early stages

In a single examination several features will suggest that the ulcer has undergone malignant degeneration such as large size of the ulcer crater An ulcer crater with a diameter of 1 inch or more should raise the suspicion of malignancy Again the presence of a filling-defect immediately adjacent to the crater should raise suspicion Care must be taken not to mistake the gap caused by mucosal oedema for a circumferential filling-defect Occasionally some thickening may be evident on radioscopic palpation

Kirklin has emphasised by the adoption of the term *meniscus* an

Figs. 63 Stages in the development of a carcinoma of the pyloric antrum (a) Early stage (b) Four months later (c) Ten months later The condition was diagnosed radiologically at the first examination but the patient refused operation

appearance seen in many malignant ulcers of and near the lesser curve. The meniscus appearance consists in a translucent zone, 1 or 2 mm in width, separating the barium filled crater from the main barium mass filling the gastric lumen (Fig. 64). He states that this is due to the growing malignant edge of the ulcer. It is an appearance which should raise the suspicion of



FIG. 64.—Malignant ulcer high up on the lesser curve showing the meniscus effect

malignancy, but the writer has observed it in several cases ultimately proved to be innocent. In these the marginal oedema was the cause of the meniscus.

If the case be under repeated radiological observation during medical treatment, failure on the part of the mucosal oedema to subside, and of the crater to shrink, would also raise the probability of malignancy. It should be emphasised that many of these malignant ulcers are very slow growing and

that the gastric acidity may be normal. Exploration should be undertaken if there is any doubt, since these malignant ulcers are more amenable to surgical removal than most gastric carcinomata.

The following table, adapted from Kirklin, indicates the main differential radiographic features in simple and malignant gastric ulcer.

	SIMPLE	MALIGNANT
SIZE	Usually 2 cm. or less	Usually more than 2.5 cm.
SHAPE	Hemispherical and sharply defined	Conical or irregular poorly defined
SITE	Usually on lesser curve distant from pylorus	Variable site but most commonly on lesser curve towards pylorus Those on the greater curve are always malignant
RGGS	Converge Corona and halo of feet if seen in face	Interrupted without convergence
PERISTALSIS	Tends to be active	Often diminished or absent
PYLORUS	Spastic if any change from the normal	Tends to gape
TENDERNESS	Present	Absent
TERAPEUTIC TEST	Heals	Enlarges or remains stationary for a time

SARCOMA OF THE STOMACH

Sarcoma, it is said, accounts for 1 per cent of all gastric tumours. It is virtually never diagnosed radiographically so closely does it simulate carcinoma in a radiogram.

Clinical Features—The age incidence for sarcoma of the stomach is rather earlier than that of carcinoma beginning at 20-30, and occurring very rarely after 70. There may be few or no symptoms. Vomiting occurs in about half of the cases. A palpable epigastric tumour is common, more so than in carcinoma. Hypochlorhydria and achlorhydria may occur but less frequently than in carcinoma. Haemorrhage and perforation may take place. Pyloric stenosis is rare, and cachexia a late symptom. *Kundrat's sign*—swelling of the lymph nodes at the base of the tongue—in the presence of a palpable epigastric tumour is indicative of a lymphosarcoma.

Site of the Tumour—In 54 collected cases the distribution was as follows: greater curve 18, pylorus 14, lesser curve 1, anterior wall 8, posterior wall 8, diffuse infiltration 4, cardia 1.

Three types occur and each tends to present a different radiographic picture.

(1) **ROUND CELLED SARCOMA**—This begins in the submucous tissue, and may be diffuse or localised forming a tumour mass which encroaches on the gastric lumen. This type most common in the pyloric half of the stomach is usually mistaken for an encephaloid carcinoma or polypoid growth. It forms 60 per cent of gastric sarcomata.

(2) **SPINDLE CELLED SARCOMA**—This the next commonest type (36 per cent), tends to form a pedunculated subserous mass. It may become large

enough to fill the abdomen, and be mistaken for an ovarian tumour Cystic degeneration is liable to occur In a barium meal this type will cause a local gastric deformity of the intrinsic type, and possibly a considerable general deformity and displacement from extrinsic pressure

(3) LYMPHOSARCOMA (*Syn malignant lymphoma*)—These tumours tend to infiltrate the stomach widely, and to produce diffused thickening of its wall Other portions of the alimentary canal, such as the ileum and caecum, are frequently simultaneously involved The pyloric antrum is a favourite site, but the pylorus itself is not usually implicated, and obstruction is uncommon The growth may show nodular or polypoid excrescences

Radiological Features —These are very varied as may be gathered from the macroscopic pathology Spitzemberger has recorded a large nodular lymphosarcoma springing from the fundus and infiltrating spleen, diaphragm, and cardia Pattison records six cases and states that ulceration is rare One of his cases presented a niche deformity, while the others simulated carcinoma The radiographic features are those of filling defect, rigidity of the gastric wall and aperistalsis, but there is nothing in those features which serves to distinguish the lesion from carcinoma, for which condition it is nearly always mistaken Courtney Gage has recently described what he considers to be a characteristic appearance in the submucous pedunculated myosarcomas of the stomach These tend to necrose at their centre and produce a filling-defect like a tangerine in the middle of which is a deep ulcer niche Odquist has reported an exactly similar appearance in neurinoma of the stomach, a rare, usually benign tumour, poorly vascularised and tending to necrosis It is most commonly found on the greater curve

CHAPTER IX

MISCELLANEOUS GASTRIC CONDITIONS

CONGENITAL HYPERTROPHIC STENOSIS OF THE PYLORUS

ALTHOUGH THE history and clinical triad—propulsive vomiting, visible peristalsis and palpable tumour—on which the diagnosis of this condition rests are so characteristic as to leave little doubt as to its nature, X-ray examination forms a valuable check and becomes of prime importance when that triad is not complete.

Aetiology—Two views are held as to the cause of this condition—that the hypertrophy is a primary congenital overgrowth of muscle, alternatively that reflex spasm is the cause of the hypertrophy. It is a true hypertrophy of the circular fibre of the pyloric canal. The hypertrophy stops abruptly at the duodenum but extends to some extent into the prepyloric portion of the stomach emerging gradually into the normal. Males are affected more commonly than females in a preponderance of 4 to 1.

Technique—The babies affected are ill, wasted and enfeebled and all manipulation should be reduced to a minimum. Especially should they be protected against cold during the examination. The meal should consist of 2-3 oz of warm thin sweetened barium emulsion or a similar amount of warm milk containing barium. This can usually be given in a feeding bottle but if this is not effective the meal must be given through a catheter. The child is then laid on the X-ray couch intermittently screened for a short period to study the pyloric function and radiograms taken every half hour until the stomach is empty. Note must be kept of any vomiting during the period of examination.

Radiological Features—The appearances in the stomach after a contrast meal has been given depend on the duration of the condition.

In very young infants there is little dilatation and peristalsis is active. The cardinal sign according to *Vanwassen and Sloof* is a lengthened pyloric canal with sharp differentiation from the pyloric antrum. As little passes through the pylorus and at infrequent intervals demonstration of this very valuable sign is difficult and may be impossible. When seen the canal is not only lengthened but extremely narrow no more than the thickness of a needle. By careful palpitation it may be possible to determine the coincidence of the pyloric tumour with the pyloric end of the stomach or the pyloric canal if visualised.

The time of gastric evacuation is usually greatly lengthened. Compared

with the normal emptying rate of one to two hours the stomach may take four hours or more to evacuate its contents completely. Some variation in this may result from vomiting. This must be allowed for in attempting to estimate the severity of the stenosis from the degree of stasis. According to Strauss if less than 70 per cent of the meal has passed out of the stomach in four hours the severity of the stenosis is such as to call for operative interference.

If the condition has lasted for a month or two dilatation becomes evident. Hill describes the X-ray features at this stage as being dilatation of the stomach, deep lively peristalsis and well marked stasis in addition to the stenosed passage. The deep wide peristalsis is most marked immediately after taking the opaque cream and this is succeeded after a variable interval by atony.

In the late stages the initial hyperperistalsis is less marked and of briefer duration while the atonic dilatation increases.

CHRONIC HYPERTROPHIC STENOSIS OF THE PYLORUS IN ADULTS

F. H. Tuning has given a full description of this condition from which parts the following account is largely taken. The abnormality is a rare one.

In the Mayo Clinic eighty-one cases were found in 60,000 examinations. Tuning records three cases.

Morbid Anatomy —The essential feature is a hypertrophy of the circular muscle fibres in the last inch or so of the antrum pylori. This hypertrophy is prepyloric; the pyloric sphincter is not involved to any great extent although it may show some degree of hypertrophy also.

The causation is unknown.

Radiological Features —A consideration of the morbid anatomy will indicate the nature of the deformity which this condition produces in the barium filled pyloric antrum. Fig. 65 represents a longitudinal section through the pyloric region and Fig. 66 shows the cardinal appearances in a barium meal examination as follows:

(1) **THE PYLORIC ISTRATION** —The true pyloric sphincter usually slightly hypertrophied indents the base of the duodenal bulb.

This effect varies with the posture and pressure on the abdomen. It may disappear in the erect position.

(2) **THE PYLORIC GLEFT** —This is a sharp barium protrusion into a mucosal cleft between the true sphincter and the hypertrophied prepyloric

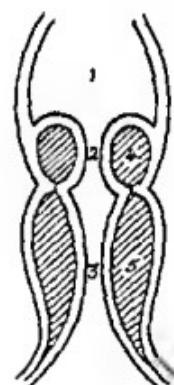


FIG. 65.—
1 Duodenal bulb
2 Pyloric canal
3 Antral lumen
4 Pyloric sphincter
5 Hypertrophic prepyloric circular muscle fibres



FIG. 66.—The barium meal illustrating the cardinal appearances of chronic hypertrophic stenosis of the pylorus in adults. For nos. 1-5 see text.



FIG. 67.—Chronic hypertrophic stenosis of the pylorus in an adult. Female, aged 3. Attacks of pain with nausea 18 years old, associated with worms. Endoscopy showed a hypertrophic, slightly palpable, contractile pre-pyloric segment. Gastric residue at 3½ hrs.

fibres. It may be mistaken for an ulcer niche but classically appears on both sides of the pyloric lumen.

(3) THE ANTRAL LUMEN.—This is considerably narrowed in its distal portion $\frac{1}{2}$ of an inch or less. The length of the narrowed portion is from

1 to 2 inches. It varies in calibre from time to time. In spite of this it never relaxes to any extent.

(4) THE PROXIMAL END OF THE STENOSED PASSAGE IS ROUND in contradistinction to that in a scirrhous carcinoma which tends to be jagged.

(5) MUCOSAL PATTERN.—In the contracted canal the mucosal folds are fine and shallow. At the proximal entrance they are contorted and may hold barium rests tenaciously.

Differential Diagnosis—These cases are nearly always mistaken for annular scirrhous carcinomata. *Turpin* diagnosed one of his three cases correctly. In considering the differential diagnosis the following points should be borne in mind. In this condition the canal shows contractility and fine mucosal folds. There is no pyloric flooding or palpable tumour. The antral extremity of the filling defect is smooth and rounded (Fig. 67).

GASTRIC DIVERTICULA

Two types are described congenital and acquired. Congenital Diverticula occur as a rule on the lesser curve near to the cardia. Rarely they are lower down on the lesser curve. *Aonjezny* has recorded one arising from the middle of the greater curve. They consist of a mucosal protrusion between the folds of the gastro hepatic omentum. In size they vary from that of a green pea to a cherry. Cases have been reported in detail by *Hurst* and *Briggs*. *L. B. Paul* has recorded six cases and states that the commonest site is on the posterior wall at the level of the cardia. Those in this position are best demonstrated with the patient supine and rotated slightly to the left.

RADILOGICAL FEATURES—If seen in profile they present a rounded regular outline with a neck of varying width and length. They fill readily during a barium meal examination and if examined in the erect position tend to show double barium fluid and air levels (Fig. 68). The diagnostic problem is to distinguish them from deep ulcer craters. Several points are of importance in this connection such as their regular rounded contours and the absence of reflex spastic phenomena gastritis tenderness or local oedema of the mucosa around the neck of the diverticulum. Careful estimation of the actual distance of the diverticulum from the line of the lesser curve may help. In diverticulum it is appreciable and real in ulcer it is only apparent. If the mucosal oedema be discounted the base of an ulcer crater is seen to be intra and not extra mural. Stasis tends to occur in diverticula and barium may be seen in them long after the stomach is empty.

A study of the mucosal relief pattern may be informative. The classic appearance of the rugae round an ulcer described under that section will be absent. It may be possible to trace the mucosal folds right into the diverticulum.

Acquired Diverticula—These are small tent like protrusions of the gastric wall resulting from the drag of adhesions. They are very rare usually seen in connection with gastric ulceration and are usually mistaken for ulcer craters.

FOREIGN BODIES IN THE ALIMENTARY CANAL

Opaque foreign bodies are instantly recognisable in a radiogram. Transparent ones can be demonstrated only if they are of sufficient size to cause a filling-defect in a barium meal.

Opaque Foreign Bodies

Of the many types of foreign bodies which may be found the following are common—pins, safety pins, hairpins, needles, nails, tacks, coins, buttons, etc.

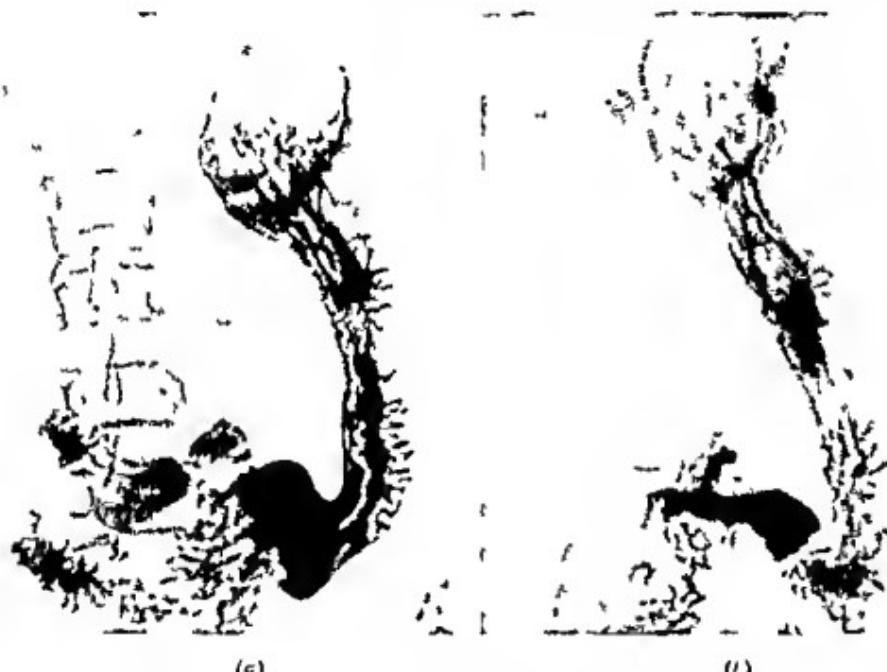


FIG. 68.—Gastric diverticulum high up on the lesser curve. (a) Postero-anterior view—note the ostium seen end on. (b) Oblique view.

Rounded objects such as coins and buttons, usually pass. Irregular objects such as tooth plates give more trouble and may become impeded. Nails and tacks pass as a rule but pins and needles, especially the latter, present a problem radiographically and therapeutically, from their tendency to penetrate the viscera in which they lie.

TECHNIQUE—In every case in which it is suspected that a foreign body has been swallowed the pharynx, oesophagus, bronchi and the whole abdomen and pelvis should be carefully surveyed fluoroscopically and radiographically. Screen examination is not enough. If that alone be used, the most dangerous type of foreign body—a pin or needle—may be overlooked. The foreign body

having been located its subsequent career should be observed in daily radiograms until it is passed. The stomach forms a common halting place. Once past the pylorus the terminal ileum is the next, then the cecum and subsequently it may be found anywhere along the colon. The gas normally present in the alimentary canal is usually enough to orientate the foreign body, but failing this an opaque meal may be given.

TRANSPARENT FOREIGN BODIES

Bodies such as fragments of bone pencils or bezoars require examination with a barium cream. If the foreign body be large it may cause a filling defect when the stomach is filled with barium emulsion. More commonly such a procedure would blot the foreign body out in the picture. Small opaque bodies can occasionally be outlined if one mouthful only of the opaque emulsion be given and the gastric mucosa outlined. The foreign body may be coated at the same time and its outlines so made visible.

TRICHOBEZOAR—A hair ball in the stomach is a rare occurrence even rarer than before because of the modern fashion of short hair among women. The size may be considerable—up to an almost complete cast of the stomach.

RADIOLOGICAL FEATURES—A large one may be visible through gas in the fundus. The upper end may be seen projecting into the gas bubble—an appearance which is quite characteristic. If a barium meal be given the hair ball will become coated with barium and so be visible. On filling the stomach completely with barium cream the hair ball forms a filling-defect which if large can hardly be mistaken for anything else. Finally after the barium cream has passed out of the stomach the surface of the hair ball will be impregnated with barium and again show a very characteristic mottled blotched appearance.

PERSIMMON BEZOAR—This bezoar is found occasionally in America. It is formed by the accumulated fibres of the persimmon fruit and forms a fibre ball with X-ray characteristics similar to those of the trichobezoar.

THE DUODENAL TUBE represents a foreign body intentionally introduced and one whose position has to be checked radiographically. The tube or terminal olive is clearly visible in a radiogram. The olive is proved to be in the duodenum when the tube itself presents a regular reversed S curve. The lower limit of the S represents the curve of the duodenum.

ASCARIDES—Dillenberger has recorded a case in which an *Ascaris lumbricoides* was demonstrated radiographically in the ileum being rendered visible by impregnation with barium sulphate after the passing of a barium meal.

DEFORMITY OF THE STOMACH FROM THE PRESSURE OF NEIGHBOURING ORGANS

Such an occurrence must always be borne in mind when confronted with a gross deformity of the stomach. The organs which most commonly act in this

way are the liver, spleen, pancreas, left kidney, and colon. Abdominal tumours and marked scoliosis may also produce deformity of the gastric contour.

These pressure deformities are infinitely variable, depending on the organ responsible.

Liver—Enlargement of the liver displaces the stomach downwards and to the left, and tends to produce a flattening of its lesser curve and a displacement of the pyloric region behind the stomach (Figs. 69 and 70). In these cases rotation of the patient into the right oblique view is necessary to view the pylorus and bulb.

Spleen—The gastric fundus and greater curve are compressed and displaced to the right in moderate enlargement of this organ. In extreme enlargement the whole stomach is displaced to the right. The spleen in a case of perisplenitis may adhere to the gastric fundus and produce a rigid flattening of its left contour.

Pancreas—Carcinoma of the head of the pancreas produces a characteristic stretching of the pyloric region and duodenal circle.

FIG. 69.—Displacement of the stomach to the left by an enlarged liver.

The duodenal area may be considerably widened and its lumen reduced to a streak. The pyloric antrum and pylorus may share in this process and at the same time be displaced upwards.

Carcinoma or other tumour of the body of the pancreas tends to cause an extrinsic central or marginal filling defect in the body of the stomach near its isthmus. In the erect position the gastric lumen is comparatively flattened from before backwards at the level of the pancreatic shelf and a tumour mass projecting forwards readily presses the posterior gastric wall forwards against the anterior. The filling defect so produced is typically exogastric. It has no clear cut margins and is readily made to disappear radioscopically by palpatory pressure on the lower pole of the stomach. A lateral view may show the actual forward projection of the tumour. Twining's method—a lateral radiogram taken of the barium filled stomach with the patient lying supine—is the best method of showing this.

Left Kidney—Only if it is grossly enlarged does the kidney displace the stomach. The displacement is forwards upwards and to the right (Fig. 70). The right kidney if very large may displace the stomach to the left (Fig. 71).

The Pregnant Uterus, large Ovarian Cysts, and other large abdominal tumours tend to raise, flatten and rotate the stomach so that its greater curve looks forwards (Fig. 72).

Gross Scoliosis, with the concavity in the left dorsal region as in the diagram causes elevation of the left dome and ballooning of the fundus (Fig. 73).

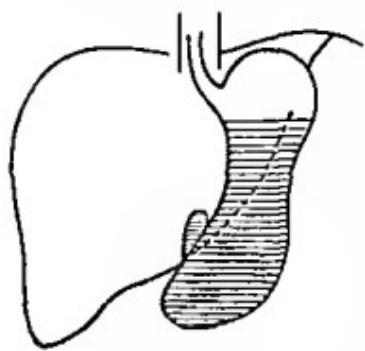


Fig. 70 Deformity of skull - presence of extra set mon (a) Frontal view (b) Lateral view
(at malleus)





FIG. 71.—Displacement of the stomach to the left by a large right hydronephrosis.

greater curve of the stomach by gas distended hastral pouches. Almost as common are the indentations of the fundus from distension of the splenic flexure. As the flexure distends it fights so to speak with the gastric fundus

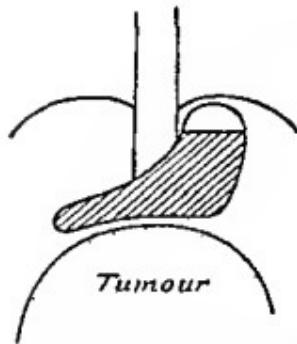


FIG. 72.—Upward displacement of the stomach by a large ovarian tumor (or pregnant uterus).

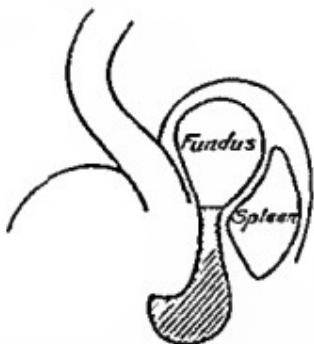


FIG. 73.—Deformity of the stomach resulting from a grossly enlarged spleen.

Colon—The position of the transverse colon and splenic flexure relative to the stomach and their mesenteric attachments account for the various gastric deformities which follow gaseous distension and displacement of the former. The deformities are very varied and range from mild indentation to complete volvulus of the stomach. The milder changes are associated with simple colonic gaseous distension, the more severe with distension plus displacement.

SIMPLE INDENTATION FROM COLONIC BALLOONING

The commonest are those produced gently



FIG. 74.—Bulging of the stomach from a gaseous tension of the left colon.

for possession of the left cupola of the diaphragm if it succeeds the gastric fundus becomes small compressed and displaced downwards to the midline

Increasing distension of the flexure commonly implicates the distal portion of the transverse colon and thus may produce an appearance of biloculation of the stomach. This biloculation if marked may simulate a cascade stomach but differs from the true physiological type in that the lower loculus is displaced to the midline (Fig. 74)

DEFORMITIES ASSOCIATED WITH DISTENSION AND DISPLACEMENT OF THE COLON —

A characteristic displacement is that in which the transverse colon travels upwards in front of the stomach and not uncommonly still farther upwards between the anterior surface of the liver and the diaphragm—the so called falciform colon or anterior hepato-diaphragmatic inter position. When this occurs the greater curve of the stomach is dragged upwards by the transverse mesocolon in front of the lesser curve and lies at an upper level. This constitutes the so called *volvulus of the stomach on its cardio-pyloric axis* (Figs. 75 and 76). The lesser curve and pylorus remain in approximately their normal positions. Again the hepatic flexure and proximal transverse colon may distort the stomach by passing up behind the liver to the right of the coronary ligament—a posterior hepato-diaphragmatic inter position.



FIG. 7.—*Volvulus of the stomach on its cardio-pyloric axis.*

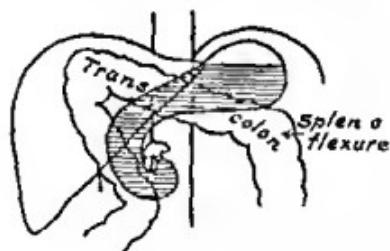


FIG. 8.—Diagram of volvulus of the stomach on its cardio-pyloric axis from anterior hepato-diaphragmatic interposition.

It is convenient to mention here the other forms of gastric volvulus which can occur. One *an acute type* is associated with a-ophageal obstruction from torsion of the fundus. Another the *volvulus on the transverse axis* presents a striking X-ray picture (Figs. 77 and 78). In this variety the stomach folds itself on a coronal axis and the antrum swings upwards in front of the body of the stomach to reach

other forms of gastric volvulus which can occur. One *an acute type* is associated with a-ophageal obstruction from torsion of the fundus. Another the *volvulus on the transverse axis* presents a striking X-ray picture (Figs. 77 and 78). In this variety the stomach folds itself on a coronal axis and the antrum swings upwards in front of the body of the stomach to reach



the left cupola near the cardia. Antrum and fundus thus lie close together the former in front. From it the pylorus points downwards to the left of the spine. The condition is best examined erect in the postero anterior left oblique and lateral views. Two barium fluid levels are evident in fundus and antrum and two corresponding air pockets.

This volvulus can take place only if the duodenum is long and has lax attachments or an actual mesentery. The aetiology is unknown. In the case of the author shown in Fig 77 there had been present a large ulcer of the lesser curve nearly healed at the time of examination. The actual volvulus was accompanied by very severe epigastric pain radiating back between the shoulders. The essential feature of all the above gastric deformities due to the colon is their evanescent quality.

PATHOLOGICAL AEROPHAGY

The swallowing of excessive quantities of air is a habit which may be distressing to the patient and still more to his or her companions. There are two types

*FIG 7.—*A*bove Volvulus of the stomach on its transverse axis and lesser curve. *B*elow Same case re-examined on the following day showing the volvulus reduced.*

In the simpler type air is swallowed in excess with each mouthful and the gas bubble in the stomach balloons out. This presses the left dome upwards and causes a feeling of discomfort and distension in the epigastrum. It is relieved by eructation a procedure which the patient may find difficult to achieve. If eructation cannot be achieved the gas must be got rid of via the intestines and so tends to cause flatulent distension.

The more severe type is found chiefly in neurotic women and is usually accomplished with much noise and fuss. A large quantity of air is noisily swallowed and distends the gastric fundus. It is soon got rid of by belching. At times the intake and ejection of the air is so rapid that it has no time to reach the stomach—the so called oesophago-aerophagy. This is often repeated a number of times in rapid succession and the general behaviour of the patient leaves no doubt as to its hysterical nature.

BORBORYGMI

This may be an embarrassing complaint for those of a sensitive disposition. The casual rumble may occur anywhere in the stomach or intestine and requires no further mention. The repetitive type follows the respiratory rhythm and occurs in the stomach or splenic flexure. Both are due to diaphragmatic movement. In the gastric type the noise is due to air being driven to and fro through the collapsed isthmus between the fundus and body of the stomach. It therefore occurs particularly in subjects with a hypotonic stomach. When the splenic flexure is filled with gas a similar process may occur.

A ray examination may give an indication as to the site in which borborygmi occur in a particular case by revealing excess of gas in either position.

RUMINATION OR MERYCISM

According to Barclay this habit is very rare in man and is sometimes hereditary. The writer had the opportunity of observing a case fluoroscopically. In this case food could be brought up into the mouth immediately after meals and this also occurred involuntarily. The act was quite different from that of vomiting. It was quiet and unaccompanied by any violent muscular activity or distress. The barium cream was seen to well quickly up the oesophagus to the back of the throat and then as quickly to descend into the stomach. The reflex appeared to be allied to that of eructation and is doubtless an exaggeration of the phenomenon of water-brash.

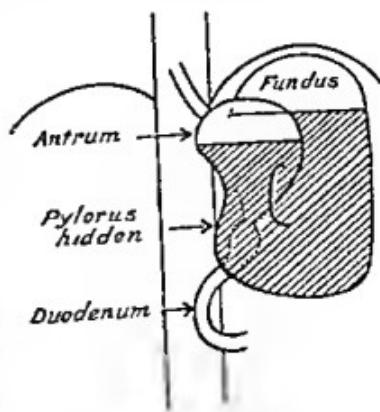


FIG. 8.—Volulus of the stomach on a transverse axis

CHAPTER X

THE NORMAL DUODENUM

ANATOMY

THE DUODENUM the shortest widest and most fixed portion of the small intestine extends from the pylorus to the duodenal jejunum flexure. It is about twelve fingerbreadths (10 inches) in length—hence its name—and describes a horseshoe curve. It is arbitrarily divided for descriptive purposes into four parts—superior descending transverse and ascending. Its course is as follows. From the pylorus the superior portion passes upwards back wards and usually with an inclination to the right beneath the quadrate lobe of the liver to the neck of the gall bladder.

It then bends sharply downwards into the descending portion along the right margin of the head of the pancreas to about the level of the upper border of the body of the fourth lumbar vertebra.

It now leads to the left across the vertebral column forming the transverse portion then upwards on the left side of the vertebral column as the ascending portion and terminates at the duodenal jejunum flexure at the level of the second lumbar vertebra.

Certain anatomical relationships are of clinical and radiological importance.

FIRST OR SUPERIOR PORTION—This is variable in position inclination and level possessing as it does a short meatus at its pyloric end. Its long axis depends on the type of stomach. In the hypertonic type it tends to run backwards to the right and slightly upwards. In the hypotonic type it runs upwards backwards and with sometimes a slight inclination to the left. Above it is the quadrate lobe of the liver. The gall bladder lies in close apposition to its upper and right surface. The head and neck of the pancreas lie below it and behind it are the gastro-duodenal artery, the common bile duct and the portal vein. This portion of the duodenum is completely covered by peritoneum except for a small triangular area posteriorly near the neck of the gall bladder. At this area the common bile duct may occasionally indent the bulb and cause a vertical linear filling defect when compression is used.

THE SECOND OR DESCENDING PORTION is covered by peritoneum in front only above and below the transverse colon. Its most important relations are the head of the pancreas, the duct of Wirsung and the common bile duct all on the inner side. The two latter traverse the duodenal wall obliquely and open together into the ampulla of Vater on the medial wall about the middle of this portion.

THE THIRD OR TRANSVERSE PORTION curves across the spine, great vessels and diaphragmatic crura to the left of the vertebral column. It is concave upwards. It is covered anteriorly by peritoneum except near the midline, where it is crossed by the superior mesenteric vessels. Above it lies the head of the pancreas.

THE FOURTH OR ASCENDING PORTION ascends on the left of the aorta for about an inch or so and then terminates at the level of the second lumbar vertebra by turning abruptly forwards and downwards to become the jejunum. It is covered with peritoneum anteriorly, and is supported at the flexure by the *musculus suspensorius duodeni of Treitz*.

Such are the classic anatomical position and relationships of the duodenum. Radiology proves them to be more variable than previously supposed, particularly the first and second portions.

The important clinical relationships are those of the first portion of the stomach and gall bladder, the second portion to the bile duct, the third portion to the superior mesenteric vessels and the whole duodenal curve to the pancreatic head, which it encircles almost completely.

Structure—The duodenum possesses an incomplete serous coat and complete longitudinal and circular muscular layers. The mucosa varies according to the part of the duodenum. The first 2 inches—that portion which forms the duodenal bulb or cap—is devoid of *valvulae conniventes*. The remainder of the duodenum exhibits the valvulae to a well marked degree. These are circularly disposed reduplications of the mucous membrane, and, unlike the gastric mucosal folds, are permanent and not obliterated by duodenal distension. This disparity in the mucous membrane in the first and the remaining parts accounts in part for the difference in the radiographic appearance between the duodenal bulb and the remainder of the duodenum.

TECHNIQUE

The duodenum must be studied fluoroscopically and in a series of radiograms, the former being in part a preliminary to the latter. Fluoroscopy is necessary not only to study the duodenum in active function but also to determine the position in which it may best be radiographed.

Posture—The erect position should be used in routine work. The majority of duodenal bulbs are best demonstrated in this position. The prone and supine positions should be tried if the erect fails to allow a satisfactory demonstration. Of the two latter the prone is more likely to present a satisfactorily filled cap than the supine.

Plane—Screen examination is also of importance to determine the exact plane in which the bulb should be radiographed. Usually an antero-posterior view is satisfactory, but at times in this the second portion of the duodenum lies directly behind the bulb, with resulting confusion of the shadows of both

Slight rotation of the patient serves to the right or left to separate the two shadows. In marked hypersthenia the right or first oblique view is necessary to show the duodenal bulb unmasks by the pyloric antrum. Two oblique views are often necessary to demonstrate the crater of a duodenal ulcer in two planes.

Pressure—Frequently it is necessary to maintain pressure on the abdomen during an exposure for two purposes in the main:

In the hypotonic individual pressure over the lower gastric pole is required in order to fill the cap satisfactorily. Again pressure over the cap is necessary in order to study its relief mucosal pattern. A transparent lamb's wool pad such as is described in the section on the technique for the stomach pressed against the appropriate area of the abdomen by the screen and cassette carrier forms the simplest means of compression. Of the mechanical compressors Berg's is the most satisfactory for the study of the duodenal mucosa.

Opaque Medium—Whatever difference of opinion there may be as to the most satisfactory vehicle for the barium sulphate in gastric examinations there is no doubt at all that a plain emulsion containing no food is the most satisfactory for duodenal investigations. The presence of food slows the rate of gastric evacuation and makes it a difficult and lengthy process to obtain a view of the duodenal bulb. The bismuth salts are to be avoided for the same reason.

NORMAL RADIOLOGICAL APPEARANCES

The duodenum can be studied only when filled with a contrast medium. On screen examination when the stomach is filled with a barium cream succeeding peristaltic waves are seen to sweep towards the pylorus and after a variable number of abortive waves the pylorus opens and a small quantity of the cream is shot upwards into the duodenal bulb. The first bolus may not be large enough to fill the bulb fully but usually after two or three similar peristaltic waves enough is ejected into the duodenum to distend it completely. The bulb retains its contents for a few seconds at most and then by a contractile wave passes the bolus on into the villous portion of the duodenum (i.e. the portion possessing plicae circulares).

The barium cream passes through the duodenum with considerable rapidity and is normally considerably subdivided by the plicae circulaires of the mucosa.

The First Portion of the Duodenum

This is by far the most important part of the duodenum from an X-ray point of view as it is the seat of duodenal ulceration.

The first portion consists of the bulbus duodeni (Fig. 79) or duodenal cap and a variable amount of feathery duodenum—the duodenum supplied with

valvulae conniventes. This is a point of importance. The normal bulb should be uniform and regular; the normal duodenum beyond the bulb should be feathery. The cap may therefore be surmounted by a feathery portion in a radiogram.

The duodenal bulb presents a wide variety of normal appearances both as to

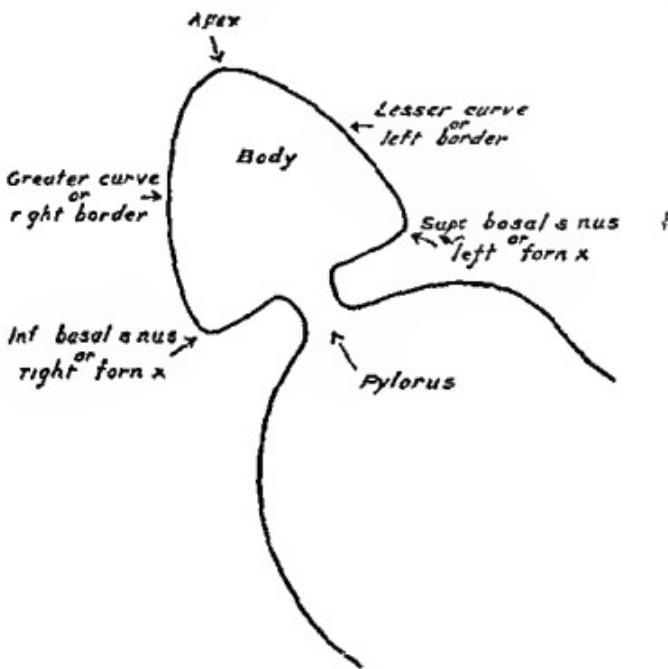


Fig. 79.—Diagram of the normal pylorus and duodenal bulb.

shape size and position. Its shape has been compared with many similes such as acorn, hazel nut, ace of spades, triangle, beehive, hemisphere etc. The acorn with its base downwards is as good a simile as any. This is the form which the duodenal bulb most typically assumes when it is full. Fig. 80 after Schinz shows the various normal types.

Features of this the standard cap are the regularly curved right and left borders and the concave base. The latter is also regular in its curve and is joined to the lateral margins by blunt angles or fornices. The concavity of the base is due to the bulge of the pyloric sphincter muscle and is increased in hypertrophy of the sphincter. The pyloric canal should join the base of the cap at its middle (Figs. 81-85).

The cap outline should be regular until a point near its apex where it is surmounted by the feathery shadow caused by the valvulae conniventes which begin at this point.

Variations in the radiographic appearance of the normal duodenal bulb may be due to

- (a) The habitus of the patient
- (b) The degree of filling
- (c) The posture of the patient.

(a) HABITS OF THE PATIENT.—The *hypersthenic* individual possesses a short squat cap, the long axis of which may be nearly horizontal and backward

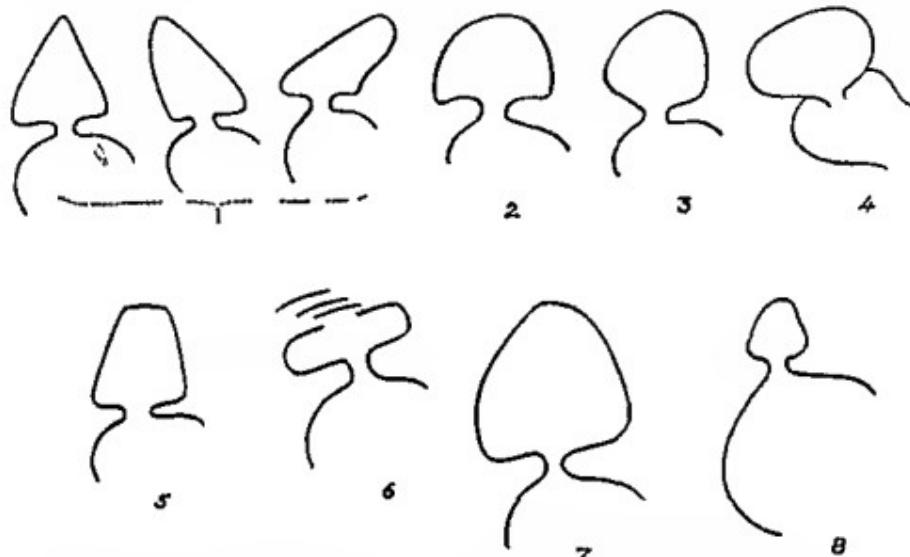


FIG. 80.—Types of normal duodenal bulb. 1 Triangular or peaked hat type. 2 Dome shaped. 3 Globular. 4 Bulbous. 5 Truncated sugar cone. 6 Hammer head shape of incomplete filling. 7 Megabulbus or justo major. 8 Microbulbus or justo minor.

inclined to some extent. In the postero anterior view the cap may be seen end on, and the lower half thereof may be hidden by the pyloric antrum. On turning the patient into the first oblique position, the pylorus and cap are seen unmasked by the stomach.

In the *orthotonic* subject, the pyloric antrum is below the pyloric level and the pylorus and bulb are seen in their entirety in the erect position. The bulb in this type is rather longer than it is broad, and a short feathery plume may be seen at its apex. The inclination of the long axis is either upwards or upwards and slightly to the right, and only slightly backwards.

In the *hypotonic* type the bulb is long and rather narrow. It points directly upwards, or upwards and to the left. Quite a large portion of feathery duodenum may surmount it.

(b) THE DEGREE OF FILLING of the cap will, of course, profoundly alter its X-ray appearance. This must be observed very carefully, as it is the commonest

cause of erroneous diagnosis of duodenal ulcer. The irregularity due to incomplete filling is usually of a recognizable type. Either a small pool in one or both of the fornices or extending right across the base or if the tone in the bulb be well maintained an outline of the mucosal pattern is visible. This last is becoming of increasing importance and a recognition of the normal folds of mucosa in a contracted bulb is essential in the determination of a barium-filled ulcer crater.

The commonest arrangement is that of longitudinal folds continuous with those of the pyloric canal (Fig. 82). These are not permanent but are obliterated by full distension of the bulb. Occasionally they assume a criss cross or honeycomb pattern and in others a radiating outline from a central barium mass. A distinctive feature of the normal mucosal rugae in the bulb is their flexibility and elasticity. They can be temporarily deformed and obliterated by pressure in contrast to their comparative rigidity in duodenitis.

(c) THE POSTURE OF THE PATIENT has a considerable influence on the X-ray appearance of the bulb. Its long axis becomes more horizontal when the patient reclines and frequently its base is hidden by the overlying pyloric antrum. This occurs particularly in hypothemic individuals in whom the erect position is



FIG. 81.—Normal bulb of the peaking flat type.

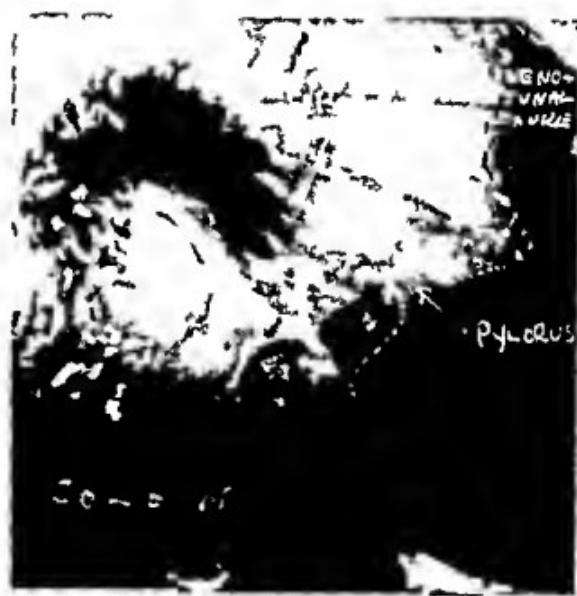


FIG. 82.—Normal duodenal bulb compressed to show the mucous pattern.



FIG. 87. Serial radiograms of the normal duodenal cycle.

the more satisfactory in which to demonstrate the cap. In the erect posture a bubble of gas is occasionally trapped in the apex of the bulb. It is of no significance except that it must not be mistaken for a bubble in a deep ulcer crater or diverticulum.

The Duodenum Distal to the Bulb

The second third and fourth portions of the duodenum show no radiographic demarcation but are merged into a more or less regular loop. As a



FIG. 84.—Normal duodenum. Serial showing the cycle of filling

rule there is a sufficient change in direction between the first or superior portion and the remainder to determine the limits of each, but even here the curve may be too regular to allow of this

On observing an opaque bolus pass through the duodenum, the cap is seen

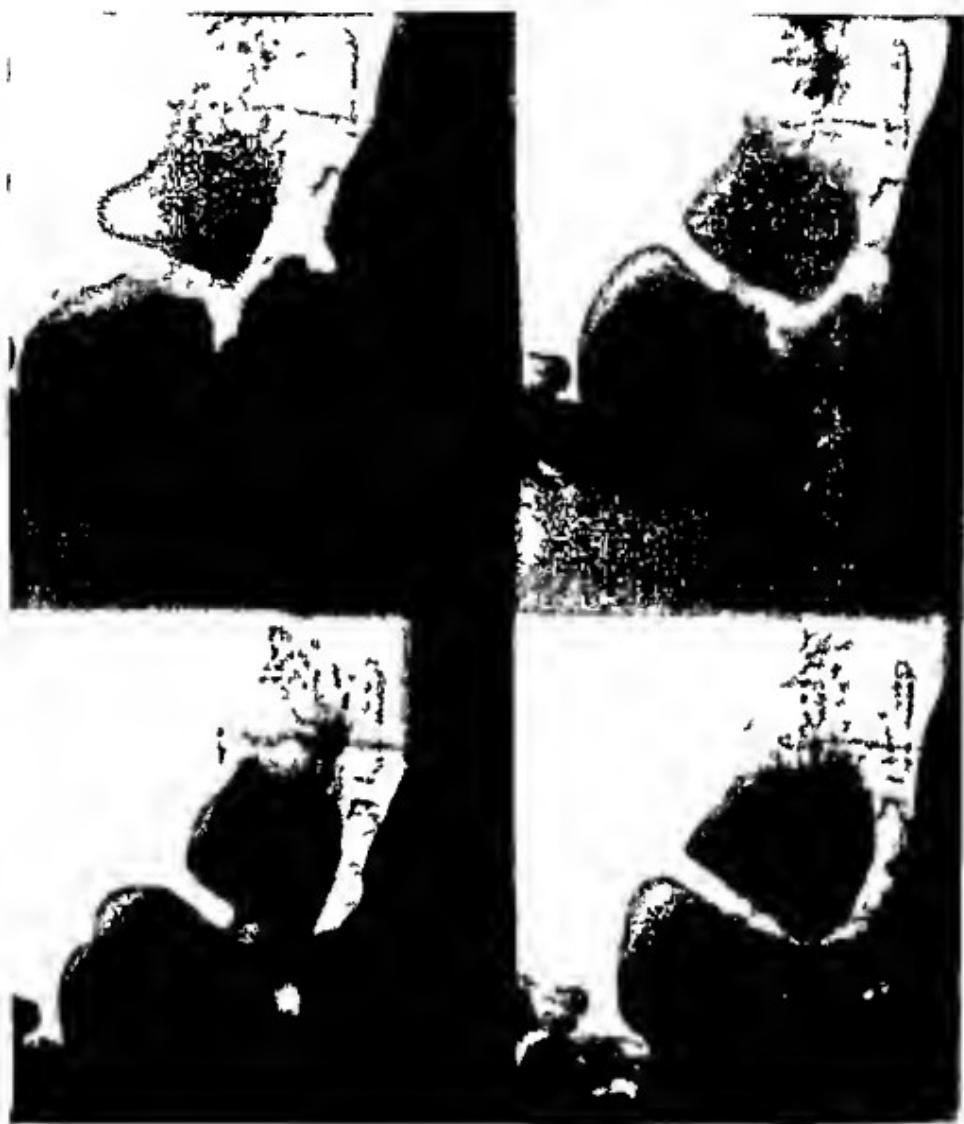


FIG. 8.—Serial radiogram of a normal duodenal bulb.

first to fill. On the bulb contracting a stream of barium is seen to sweep round the duodenum into the jejunum in a remarkably fine state of subdivision. A radiogram taken with a sufficiently short exposure will show this appearance in detail. It is unusual to see a solid mass of barium in the normal duodenum beyond the bulb unless with very free gastric evacuation. This

curious effect is produced by the *valvulae conniventes* in a way not completely understood. The mucosal pattern in the third portion may be flattened and longitudinally disposed where the superior mesenteric vessels cross the gut. This appearance is exaggerated in arterio-mesenteric disease.

AMPULLA OF VATER—In a small percentage of cases this fills with a barium cream and is visible as a small rounded shadow the size of a green pea close to the inner border of the second portion of the duodenum. Its filling does not appear to have any clinical significance except that it may simulate a duodenal diverticulum. It is unusual to find a cast retained in the ampulla after the stomach and duodenum are empty, doubtless because the biliary and pancreatic secretions wash it out.

DUODENO-JEJUNAL FLEXURE—This forms a fairly acute angle in the hyposthenic individual and often just a gentle bend in the hypersthenic. It shows no sphincteric action. In the hypotonic the opaque cream may show slight hesitation before passing this flexure but hypotonia alone rarely causes any serious duodenal stasis.

CHAPTER VI

DUODENAL ULCER AND OTHER INFLAMMATORY LESIONS

CLINICAL FEATURES

THE DUODENUM is much the commonest site of peptic ulcer duodenal ulcer being several times as common as gastric. The causation and morbid anatomy are similar to those of gastric ulcer. Thus they fall into two categories—acute erosions and chronic ulcers.

Duodenal ulcer may be met with at any age but in the main it is a disease of adult life. In children the condition is very rare and if present is usually in the form of an acute erosion. The greatest age incidence is between 30 and 50 years. Males are more often attacked than females in a ratio according to *Sherren* of 4 to 1. There is an association between duodenal ulcer and chronic appendicitis the latter standing in a causal relationship to the former.

Situation—Over 90 per cent of duodenal ulcers are situated in the first inch of the duodenum. According to *Clairmont* the commonest site is on the anterior wall next in order of frequency the posterior wall. Sometimes two are present opposite one another the so called kissing ulcers.

Perforation—This may be acute or chronic. In the former the contents of the duodenum flood the abdomen. In the latter the perforation is walled off by adhesions of a nearby viscus and a localised peri-duodenal cavity or accessory pocket is formed.

RADIOLOGICAL FEATURES

The X-ray signs of duodenal ulcer may be grouped as follows:

- (a) The visualised ulcer crater
- (b) Adjacent inflammatory spastic and cicatricial changes in the bulb
- (c) Secondary disturbances in the stomach

The Visualised Ulcer Crater

This is the one cardinal and pathognomonic sign of duodenal ulcer. All other signs are susceptible in occasional instances to other explanations.

Barclay first drew attention to the persistent fleck as a sign of duodenal ulcer. Years were to elapse before the occasional recognition of a barium residue in an ulcer crater in the duodenum was elaborated by him and his pupils in England and by *Akerlund* in Stockholm, into a systematic demonstration of the ulcer crater in the majority of cases but to *Barclay* is due the credit of introducing the direct sign in the diagnosis of this condition.

Although in the majority of cases the duodenal bulb shows a deformity in part due to other factors that due to the ulcer itself is of primary importance and a careful attempt must be made to demonstrate it in every case (Figs. 86-89). Berg in recent years has stressed the importance of this and the technique



FIG. 86.—Duodenal ulcer on anterior wall *en face* and *en profile*. Note the mucosal corona brought into view by compression.



FIG. 87.—Duodenal ulcer on the posterior wall seen *en face* and *en profile*.

associated with his name is the basis of modern examination. Berg aims at showing the ulcer crater in two planes, *en profile* and *en face*. The essence of his method is to use aimed exposures to show the niche in profile and to use graduated compression over the bulb to show the ulcer *en face*. For the profile view screen examination is necessary to decide the precise angle in which the radiogram must be taken and rotation of the patient through approximately 90 degrees should then bring the ulcer *en face*. Mather Cordner points out that as the majority of ulcers of the bulb are on the antero-lateral and

postero medial surfaces, the profile niche is usually best seen in the left anterior oblique position, and the *en face* in the right anterior oblique.

The *en face* ulcer will be invisible in a well filled bulb, and Berg uses his "graduated compression" over the bulb to flatten it, partially empty it, and so bring the relief pattern of the duodenal mucosa into relief.

This technique finds its particular value where spasm, oedema and scarring of the bulb are all present in slight degree or not at all. In such cases an anterior or posterior wall ulcer might be entirely obscured in a well filled cap, unless carefully sought for in this manner.

An ulcer crater seen face on may show a different appearance, depending on the degree of pressure used, the depth of the ulcer, and the amount of oedema round it. Thus a deep crater, with little compression, may show a diverticular opacity with a fluid level and gas above. A medium crater with surrounding



FIG. 88.—Three views of a duodenal bulb. (a) Postero-anterior with compression; one ulcer crater visible. (b) With patient slightly rotated two are now visible (superimposed in the first view). (c) Lateral, showing ulcer craters on anterior and posterior walls (*kissing ulcers*). The pylorus is marked X.

oedema and considerable pressure produces the "rosette" appearance (*la cocarde* of the French) that of a round central opacity and a surrounding translucent zone. A shallow crater with little or no oedema, tends to show a star shadow, a central fleck with a radiating corona of mucosal phee. Forsell has emphasised this radiation of the phee as a sign of a contracting ulcer.

This demonstration of the ulcer crater in two planes, profile and end on, is a counsel of perfection unattainable in some cases. Often in the obese hypersthenic subject whose duodenum is placed high under the costal arch and is not susceptible to radioscopic compression the *en face* picture is not feasible. Again in such subjects the bulb may be hidden behind the pyloric antrum, and only one unobscured view be possible—one which may or may not be the correct one for the profile view of the ulcer. In other cases the other factors may distort the bulb so grossly that the Berg technique is either unnecessary or ineffective. Indeed most ulcers of the duodenum present a bulb deformity

due in part to other factors. In some the crater is evident, in others the distortion is so gross that it is impossible to be certain what is ulcer crater either *en face* or in profile, and what is a crevice of normal mucosa thrown into prominence by the surrounding deformity.

In such cases it is of first importance to establish one point regarding the deformity, whether or not it is constant. Since an essential feature of bulbar



FIG. 81.—*Above*. Right and left oblique views of the duodenal bulb taken without compression. *Below*, *c.* The same views taken with compression, *a* and *b*, showing a duodenal ulcer in its two planes.

deformity due to ulcer is its constancy; the importance of taking a considerable series of radiograms is obvious.

Some variation in the appearance must result from the varying degree of distension as the bulb fills and empties, but discounting this the deformity must remain substantially the same in type and disposition if it is to have any significance.

Adjacent Changes in the Bulb

These factors which produce superadded deformity in the bulb—mucosal oedema, muscular spasm, cicatricial contracture, and peritoneal adhesion—all



FIG. 90.—Serial radiograms of a duodenal ulcer producing a general bulb deformity of the pine tree or coral branch type.

tend to encroach on the duodenal lumen. Oedema tends to produce a rounded inward bulge spasm a sharper indentation and scarring may assume any form. Periduodenal adhesions may produce contracture or 'tenting'.

By the varying interplay of these five factors—ulcer crater, oedema, spasm, scarring and adhesions—an almost infinite variety of bulb deformities may be produced, but they tend to fall into several groups.



Fig. 91.—Several radiograms showing general bulb deformity from duodenal ulcer.

(1) GENERAL BULB DEFORMITY.—The great majority of ulcers fall into this group. Of the many metaphors used to describe this type the terms "coral ranch," "shamrock" or "pine tree" deformities are the most commonly applicable (Figs. 90-94). In these deformities the actual crater can fre-

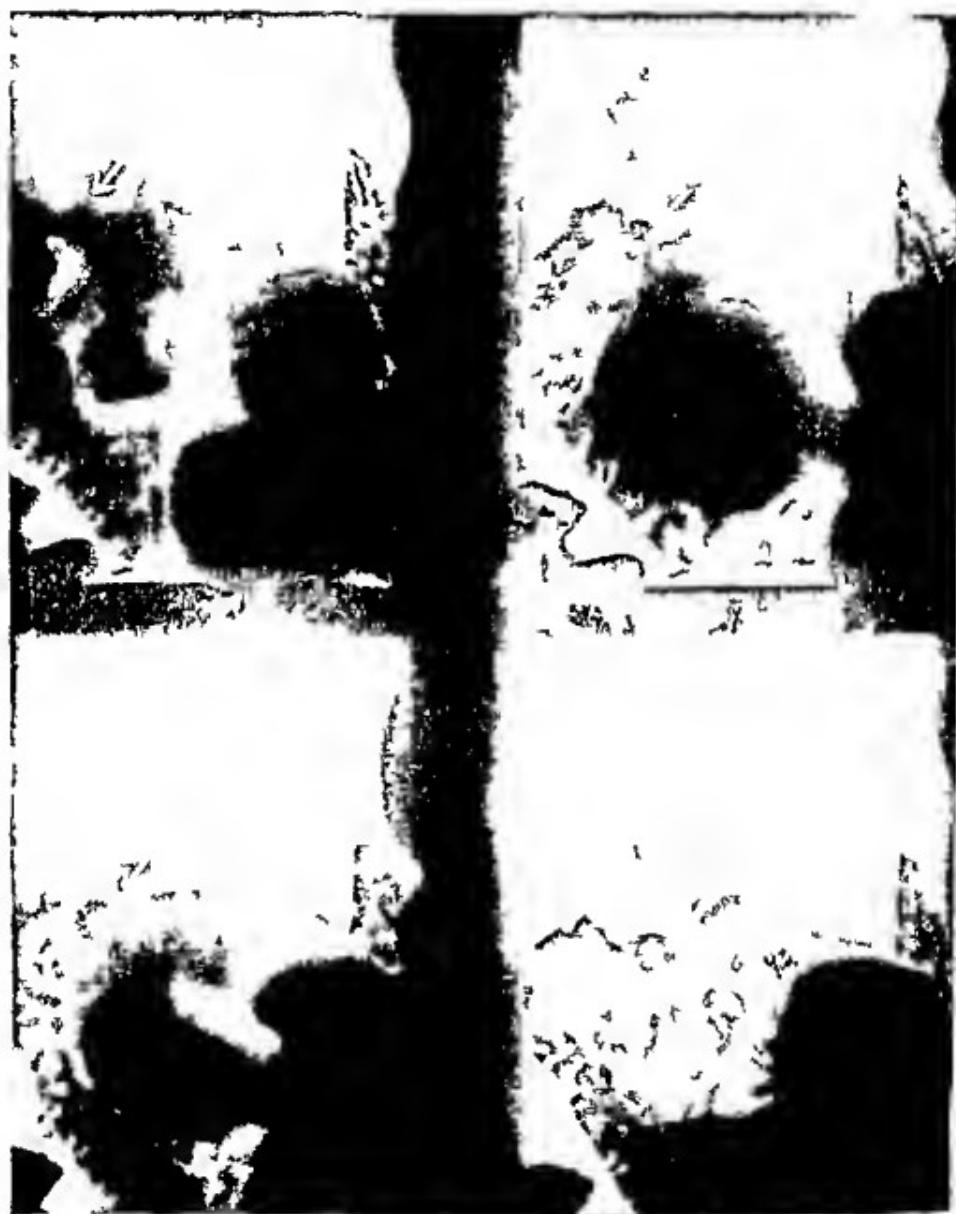


FIG. 5. Serial roentgenograms of a stenosing ileocecal valve.

quently be distinguished and beside it the spastic and edematous elements. Scarring can only be determined after repeated observation during a course of successful medical treatment. It cannot be separated from the other two or its

presence definitely determined at one initial examination, unless there are indications of obstructive stasis in the stomach. Then scarring sufficient to produce obstruction can be inferred.

(2) NICHÉ DEFORMITY.—This type, already described above consists of a protrusion of the barium filled crater seen in profile. It is relatively uncommon alone.

(3) AN INCISURA DEFORMITY may be seen in a radiogram and usually means the presence of an ulcer. A careful search, after the manner of Berg should be made in such a case to demonstrate the actual crater.

(4) The ÅKERBLUND DEFORMITY a combination of niche and incisura is a

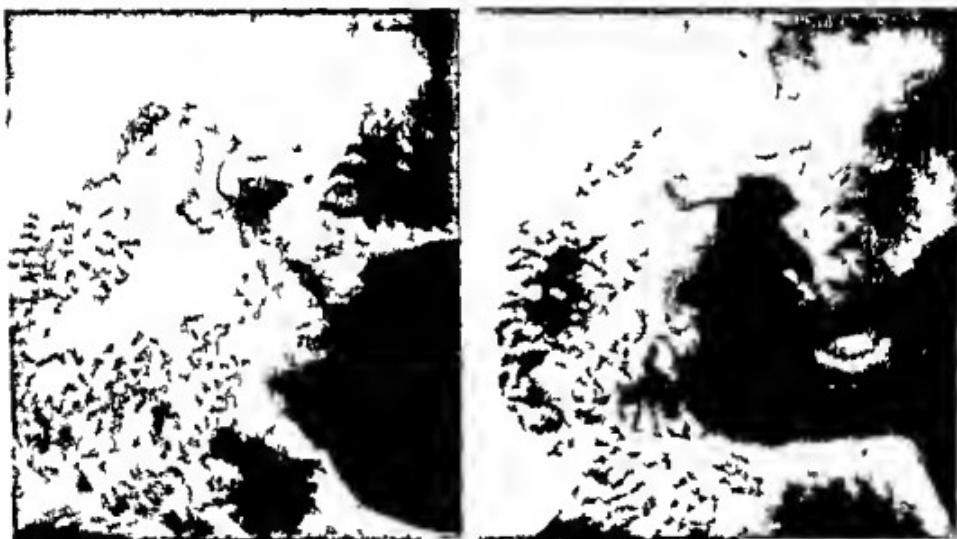


FIG. 33.—Duodenal ulcer: two phases of filling.

very typical appearance with the niche on the lesser curve (left border) and the incisura on the right border. It does not occur frequently (Fig. 33).

(5) DEFORMITY OF THE BULB ASSOCIATED WITH DISTORTION OF PYLORIC CANAL.—This occurs typically when the ulcer spreads from the duodenum into the pylorus. The base of the cap is of necessity deformed at least on one side by such an ulcer. The pyloric canal is commonly eccentric relative to the bulb in such cases.

(6) RETRACTION (ÅKERBLUND).—Åkerblund has described a change in the bulbar contour in the region of the ulcer crater to which the above term has been applied. It consists of a loss of convexity or actual concavity of the contour of the cap on either side of an ulcer seen in profile. He attributed this to muscular retraction round the crater, but *Berg's* explanation—that of mucosal oedema round it—is the more probable.

(7) THE SMALL STENOSED BULB—Marked scarring associated with ulceration may produce an irregular microbulbus. Associated with this there is not infrequently a dilated pouch formed by the base of the bulb (usually the right fornix thereof). This type was first described by Akerlund and the dilated pouch has been called the 'prestenotic diverticulum' (Fig. 96).

(8) DEFORMITY FROM PENETRATING ULCER THE ACCESSORY POCKET—An accessory pocket results when an ulcer perforates the duodenal wall and forms a localised periduodenal cavity. It is an uncommon occurrence and may persist as one type of secondary duodenal diverticulum. In the erect position it typically displays after a barium meal has been given the three layers already described in connection with gastric ulceration—gas fluid and barium from above downwards. It must be distinguished from a supraampullary primary duodenal diverticulum the only other condition which can simulate it. In the latter the cap outline is normal while with a penetrating ulcer there are certain characteristics in the radiographic appearances to which Mather Cordiner has drawn attention as follows:

When an ulcer has penetrated into a neighbouring organ—e.g. liver or pancreas—the cap loses its mobility. If the pancreas is involved the posterior wall of the duodenum is drawn out into a peak or tent when put on the stretch. A diverticular crater may surmount this. Occasionally the normal longitudinal mucosal folds can be seen bending abruptly into the funnel-shaped channel to the crater. This dragging on the bulb tends to foreshorten it. The above signs may be tabulated thus:

- (1) Fixation of bulb
- (2) V-shaped deformity with niche
- (3) Accessory pocket or diverticulum
- (4) Divergence of rugae into the funnel-shaped channel
- (5) Foreshortening of bulb

Secondary Disturbances In the Stomach

The most frequently observed of these is *hyperperistalsis*. It is held by some that this is evidence merely of a predisposing habitus but in many cases it is too marked in degree to be accounted for on that ground and must be explained as a reflex from the duodenal focus of irritation. This hyperperistalsis occurring with a patent pylorus results in rapid gastric evacuation.

Increase in the thickness of the gastric rugae especially along the greater curve is a common occurrence. This is shown in the filled gastric lumen by crenation of the greater curve and by widening of the rugae in the relief pattern. It is commonly ascribed to an associated gastritis but may also be a reflex phenomenon on the part of the gastric mucosa and muscularis mucosæ.

Hypertonus is frequently seen but unlike hyperperistalsis can be accounted for as merely an indication of the habitus of the patient. Duodenal ulcera-



FIG. 94.—Ulcer crater posterior wall of bulb seen en face with mucosal corona.



FIG. 95.—Ulcer crater in the right fornix of the bulb in which barium has settled. Associated spasm of the left border.



(a)

FIG. 96.—(a) The pre-stenotic diverticulum of Auerhahn. (b) Ulcer crater on the base of the duodenal bulb.



(b)

tion though commoner in persons of hypersthenic build is by no means confined to them, and hiccuping and slow evacuation are not uncommonly present. Indeed, the observations of *Hurst* regarding the pyloric function in gastric

(7) THE SMALL STENOSIS BULB—Marked scarring associated with ulceration may produce an irregular microbulbus. Associated with this there is not infrequently a dilated pouch formed by the base of the bulb (usually the right fornix thereof). This type was first described by Akerlund, and the dilated pouch has been called the "prestenotic diverticulum" (Fig. 96).

(8) DEFORMITY FROM PENETRATING ULCER, THE ACCESSORY POCKET—An "accessory pocket" results when an ulcer perforates the duodenal wall and forms a localised periduodenal cavity. It is an uncommon occurrence, and may persist as one type of secondary duodenal diverticulum. In the erect position it typically displays, after a barium meal has been given, the three layers already described in connection with gastric ulceration—gas, fluid, and barium from above downwards. It must be distinguished from a supraampullary primary duodenal diverticulum, the only other condition which can simulate it. In the latter the cap outline is normal, while with a penetrating ulcer there are certain characteristics in the radiographic appearances to which *Mather Cordiner* has drawn attention as follows:

When an ulcer has penetrated into a neighbouring organ—e.g. liver, or pancreas—the cap loses its mobility. If the pancreas is involved, the posterior wall of the duodenum is drawn out into a peak or tent when put on the stretch. A diverticular crater may surmount this. Occasionally the normal longitudinal mucosal folds can be seen bending abruptly into the funnel shaped channel to the crater. This dragging on the bulb tends to shorten it. The above signs may be tabulated thus:

- (1) Fixation of bulb
- (2) V shaped deformity with niche
- (3) Accessory pocket or diverticulum
- (4) Divergence of rugae into the funnel shaped channel.
- (5) Foreshortening of bulb

Secondary Disturbances in the Stomach

The most frequently observed of these is *hyperperistalsis*. It is held by some that this is evidence merely of a predisposing habitus but in many cases it is too marked in degree to be accounted for on that ground, and must be explained as a reflex from the duodenal focus of irritation. Thus hyperperistalsis occurring with a patent pylorus results in rapid gastric evacuation.

Increase in the thickness of the gastric rugae, especially along the greater curve, is a common occurrence. This is shown in the filled gastric lumen by crenation of the greater curve and by widening of the rugae in the relief pattern. It is commonly ascribed to an associated gastritis, but may also be a reflex phenomenon on the part of the gastric mucosa and muscularis mucosae.

Hypertonus is frequently seen, but unlike hyperperistalsis can be accounted for as merely an indication of the habitus of the patient. Duodenal ulera



FIG. 34.—Ulcer crater posterior wall of bulb seen en face with mucosal corona



FIG. 35.—Ulcer crater in the right fornix of the bulb in which barium has settled. Associated spasm of the left longitudinal muscle.



(a)

FIG. 36.—(a) The prestenotic diverticulum of Mecklin I. (b) Ulcer crater on the base of the duodenal bulb



(b)

tion though commoner in persons of hypersthenic build is by no means confined to them and hypotonia and slow evacuation are not uncommonly present. Indeed the observations of *Hurst* regarding the pyloric function in gastric

ulcer and its effect on the function of the stomach apply with equal force here. In duodenal ulcer there may be found one of the three abnormalities of the pylorus—achalasia, pylorospasm, or organic stenosis, or a normal pyloric function may obtain.

These gastric changes constitute, therefore, interesting but unimportant confirmatory parts of the radiological picture of duodenal ulceration, and of themselves afford no specific diagnostic indication of ulcer in that site.

In a certain percentage of cases localised tenderness on pressure over the duodenal lesion is present. It is said to be the result of peritoneal involvement and periduodenal adhesions. It is a variable sign. Frequently the tender point is in the epigastrium well above the duodenal bulb. It is of no value as an independent sign.

The last word in the discussion of the X-ray diagnosis of duodenal ulcer should be to emphasise the cardinal importance of the niche, the ulcer crater itself. Too often it is not possible to demonstrate it, and reliance must be placed on the general bulb deformity—the coral, the pine tree, the clover, etc. While these are most commonly due to duodenal ulceration they may result, in occasional cases, from such diverse lesions as healed ulcer, duodenitis, cholecystitis, appendicitis, periduodenitis, or even mere incomplete filling.

The niche itself properly demonstrated end on and in profile is the only pathognomonic sign of active ulceration, and the other deformities of the bulb are more properly indices of associated oedematous, spastic, or cicatricial changes.

Healing of a Duodenal Ulcer—This is a problem which frequently presents itself in radiological practice, and is often a difficult one. Whilst it may be fairly simple to establish the presence of a duodenal ulcer initially, it is often a matter of great difficulty to decide how much residual deformity will ultimately occur on healing.

In considering this the factors producing the deformity must be borne in mind, and it is of first importance that the initial radiograms of the ulcer and the succeeding check examinations be of the highest quality. Only then can the gradual disappearance of the deformity be analysed.

To determine the presence of a healing process the ulcer crater should be looked for first. It must disappear. Its radiographic disappearance is not conclusive, as the crater may be visible only because of the surrounding mucosal oedema. The oedema is usually the first of the factors to disappear. In the case where the crater is invisible on the disappearance of the oedema the persistence of a spastic incisura of the bulb may indicate that the lesion has not entirely healed. The spasm is, as a rule, the last temporary factor to disappear, leaving a varying cicatricial residue. This last may range from a virtually normal bulb outline to quite marked stenotic deformity. In the latter case, the fact of healing cannot be established by radiographic means alone. In the presence of marked cicatrification prolonged absence of all symptoms would be necessary to warrant such a conclusion.

It follows from the above considerations that a healed duodenal ulcer can with certainty be shown radiographically to be so only if no cicatricial deformity remains after healing. The more the residual scarring, the less certainty is there in the radiographic demonstration of healing, and the more reliance must there be placed on the clinical evidence on this point.

In an extreme case, where a secondary diverticulum has followed ulceration, it may be quite impossible to distinguish this from a deep ulcer crater but the deepest of craters usually shows some lessening of size under vigorous medical treatment, and if no diminution in size is observable in a series of examinations spread over a course of treatment, the presence of a secondary diverticulum or pouching is to be suspected rather than that of a deep ulcer.

Gastric Stasis following Duodenal Ulcer.—This is a not uncommon sequela of chronic duodenal ulceration, and is caused chiefly by cicatricial contraction, with a superadded element of oedema, if active ulceration persists, as it usually does.

In the less severe degrees it may be easy to demonstrate the stenosed irregular passage, but in the severe degree this may take considerable pains and patience. The secondary gastric signs, as described under pyloric stenosis will be present to an extent depending on the severity of the narrowing.

It may not be possible to determine whether the obstruction is in the bulb alone or in the pylorus as well, but the point is of little importance, so long as there is no sign of involvement proximal to the pyloric ring. This would raise the possibility of carcinoma a condition which may virtually be left out of consideration on the distal side of the sphincter.

DUODENITIS

This has become a popular diagnosis of recent years and although doubt has frequently been cast on its existence, it has now been proved pathologically to be a clinical entity. A certain degree of duodenitis nearly always accompanies a duodenal ulcer, but Kirklin has published a series of thirty two cases in which the presence of duodenitis and the absence of an active or healed ulcer have been proved histologically.

The bulb is the most common site but the inflammatory process may extend down as far as the ampulla of Vater (i.e. the point of acid neutralisation). McCarty gives an account of the pathological features as those of cellular destruction with oedema, vascular congestion, and leucocytic infiltration. Macroscopically, the mucosa is oedematous and reddened, with occasional minute erosions.

THE X-RAY FEATURES are dependent on spasm of the muscularis and oedema of the mucosa. The changes may be seen in the bulbar and post-bulbar portions, and in the filled and empty lumen. In a marked case they are fairly typical.

In the bulb, the first point to be noticed is its filling. Owing to general

increased tonus in the bulb the contrast medium when projected through the pylorus fails to distend the cap to its normal proportions and whatever incomplete filling does occur is speedily dispersed. A radiogram taken at the moment of filling shows a small cap with a hazy or spiky contour. If taken a second or so later the mucosal pattern of the bulb becomes visible (if not of itself then with graduated compression). It takes the form of a coarse reticulum the result of broadening and coarsening of the mucosal folds. Together with this broadening is a loss of flexibility so that it is difficult to obliterate them by pressure. Between the folds there may occur irregular deposits of barium simulating an ulcer crater but no true ulcer crater is seen. This though a negative statement requires emphasis since the presence of such a crater must be meticulously excluded before pronouncing the condition to be the simpler one. Distinguishing features are the absence of a niche projection in profile and the inconstancy of the pseudo niche at subsequent examination.

The duodenum between the bulb and the ampulla is involved in the inflammation, shows radiographic changes depending on the degree of mucosal oedema and muscular hypertonus.

During the phase of filling the barium filled lumen is seen to be narrower and its margins scalloped to some extent. The latter is due to the indentation of the barium shadow by the oedematous mucosal plicae. When peristalsis has emptied the lumen a coarse mucosal pattern is visible similar to that seen in the bulb.

According to *Kirklin* duodenal obstruction rarely results from simple duodenitis nor is gastric stasis a feature thereof.

PERIDUODENITIS

This too is a popular diagnosis of recent years and there is a tendency so to label any vague irregularity in the duodenal contours in which no very definite pathological lesion is demonstrable. It is a comfortably vague and non-committal diagnosis one which does not tempt to surgical interference and one to be avoided unless on the clearest possible evidence.

Durat describes two types periduodenitis involving the bulb and peri-duodenitis involving the third and fourth portions.

BUHLER PERIDUODENITIS may involve the whole bulb or merely the apex. In the former the bulb is small, adherent, irregular in contour and inextensible. Its differentiation from true duodenitis would thus depend on the demonstration of a normal mucosal pattern in the bulb a thing rather difficult to do because of the serous thickening. In the type limited to the apex of the bulb the main body of the bulb is normal in contour and only its apex shows irregular constant contracture. Various causes are ascribed to this condition. In some no cause is demonstrable others result from cholecystitis, duodenal ulcer, or adhesions. It is obvious that in those cases in which the primary cause in the gall bladder or duodenal mucosa is visible the periduodenitis is an inci-

dental state quite overshadowed by the major lesions, and the closest search must be made for such primary condition in all cases in which a suspicion of bulbular periduodenitis is raised by the radiological examination. The demonstration of duodenal ulcer and gall bladder disease is as a rule easy, and any considerable adhesions may cause a displacement of the bulb either in front of or behind the stomach. The anteposed bulb may result from its adhesion to a large dilated gall bladder to the anterior edge of the liver, or to the anterior abdominal wall. The retroposed bulb is usually adherent to a small retracted gall bladder, or to Spiegel's lobe of the liver.

PERITRODENTIS OR THE THIRD AND FOURTH PORTIONS results in a mild stenosis and a mild duodenal ileus. Its appearances are discussed in that section.

PERITRODENTIS AFTER CHOLECYSTECTOMY —The duodenal bulb very commonly shows a deformity following this operation, the result of adhesions. These if marked may cause duodenal stenosis and consequent post-operative abdominal symptoms. They may, however, exist in the presence of complete clinical cure.

DUODENAL FISTULÆ

These may be external or internal.

EXTERNAL FISTULÆ are rarely seen in X-ray departments. They may result from operations on the duodenum, bile tract, or right kidney, or be due to pathological conditions of the duodenum (notably ulcer) or to injury. The condition is usually evident clinically from the nature of the discharge and its digestive effect on the skin, but in those cases where there is slight discharge only and little cutaneous reaction the nature of the fistula can easily be determined by injection of an opaque medium, e.g. barium cream, sodium iodide or lipiodol and its radiographic demonstration in the duodenal lumen.

Of the INTERNAL FISTULE the *cholecysto-duodenal type* is by far the commonest. These result usually from ulceration of a gall stone through into the duodenum or from perforation of the gall bladder by a duodenal ulcer. Fistulae due to carcinoma have been recorded. The radiographic demonstration of these fistulae depends on observing the passage of a barium meal into the gall bladder. If the bile ducts also fill, the nature of the condition is evident, but if not, a lateral radiogram is necessary to differentiate the barium-filled gall bladder from a duodenal diverticulum.

The next commonest type according to Naunyn and Roth are the *choledocho-duodenal fistulae* arising from ulceration of a gall-stone impacted in the common bile duct. With good fortune barium may pass into the bile ducts and render the fistula evident radiographically, but this does not always occur. Rarer fistulae are those between the duodenum and the stomach, colon and right renal pelvis respectively. The *duodeno-gastric type* is best demonstrated by a barium meal, the others by a barium enema and instrumental pyelogram respectively.

CHAPTER XII

MISCELLANEOUS DUODENAL LESIONS

DUODENAL DIVERTICULOSIS

THE DIAGNOSIS of this is exclusively radiological as the majority of cases are symptomless and in the rest the symptoms are in no way characteristic. Case in 1913 was the first to diagnose a case by a barium meal.

FREQUENCY.—Linsmayer, in 1,367 autopsies, found duodenal diverticula in 33 per cent of cases.

The percentage found in barium meal examinations varies, according to different investigators between 18 per cent and 519 per cent. Case (1920) in 6,847 barium meal examinations, found diverticula in 12 per cent and Spriggs 38 per cent in 1,000 cases.

CLASSIFICATION.—Odger's grouping appears to be the most satisfactory. He divides duodenal diverticula as follows: primary, secondary, and ampullary (Fig. 97).

Primary Diverticula

The diverticula of this group show the following characteristics:

(1) They occur only in the second, third, and fourth parts of the duodenum.

The second portion is much the commonest site, about 75 per cent of all primary duodenal diverticula being in this segment. A large majority are situated within an inch of the ampulla of Vater—the "diverticules perivateriens" of Letulle. A second fairly common site is at the duodenal flexure. Here they project upwards.

(2) They are sometimes multiple, two being present, and, rarely, three. When two are present, they are commonly situated one on either side of the ampulla.

(3) They are more commonly on the concave surface of the duodenum and grow into, behind, or against the head of the pancreas. Sometimes they lie behind the duodenum, and if large they may sag downwards and lie below the duodenum.

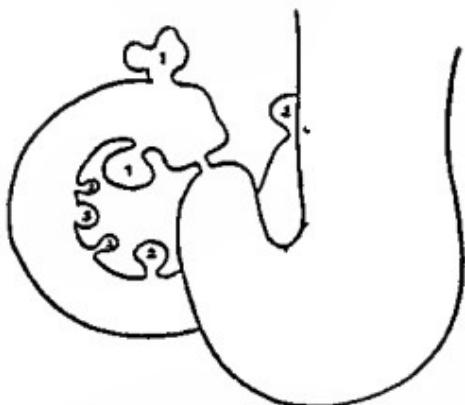


FIG. 97.—Types of duodenal diverticula.
1 Secondary 2 Primary 3 Ampullary

- (4) They are flask shaped mucosal protrusions of the mucosa through the muscular coat, sometimes carrying with them an expansion of the muscularis
- (5) They are best developed in elderly patients
- (6) In size they vary from a pea to a walnut
- (7) They are probably of congenital origin

Kellogg divides the above class into true and false diverticula according to the composition of the wall thereof. The true diverticula have a wall including all coats of the duodenum. These he regards as congenital. False diverticula, he states, are acquired and are composed mainly of mucosa.

PATHOLOGY—The great majority of these diverticula are discovered accidentally and cause no pathological changes. In a small number of cases changes do occur and are associated with symptoms. *Odger* gives a full account of the sequelæ which may occur the best established of which are:

- (1) *Diverticulitis*—This may go on to ulceration and perforation.
- (2) *Peridiverticulitis* with adhesions to the pancreas.
- (3) Mechanical compression by a distended diverticulum on the duodenum and common bile duct, causing duodenal ileus and biliary obstruction respectively.

Duodenitis cholangitis acute and chronic pancreatitis are rarer complications which have been described. In one case a cholesterol stone was found in a diverticulum.

THE SYMPTOMATOLOGY in those cases which give rise to symptoms falls into one of several groups:

- (1) Vague digestive disturbance with distension, flatulence, and nausea.
- (2) Peptic ulcer symptom complex.
- (3) Biliary symptoms, with jaundice and colic. These occur particularly in periantral pouches.

(4) Symptoms of acute pancreatitis

X-RAY FEATURES—The characteristic feature is the presence of one or more rounded barium shadows near the concave border of the duodenum (Figs 98, 100). Under screen examination the pouch can be made to fill from



FIG. 98.—Small duodenal diverticulum near the ampulla.

and empty into the duodenum and tenderness over the shadow indicative of diverticulitis may be determined. Fixation of the diverticulum may be noted on palpation. This is of no great significance since while it may be due to peridiverticulitis it may be due merely to the pouch being deeply embedded in the pancreas. The presence of stasis in the pouch is of importance (Fig. 101). The writer has seen two cases in which a peptic ulcer symptom-complex was present and in which six hour stasis occurred. In one



FIG. 101. Large diverticulum (1) of the second portion of the duodenum. Stasis occurred in it up to 6 hours. The greater curve of the stomach shows an associated gastritis.

of these cases removal of the diverticulum was followed by disappearance of the symptoms.

The mucosal relief pattern may in some cases be traced from the duodenum through into the pouch.

Usually the erect posture is sufficient to show these diverticula and in this position a horizontal fluid level may be visible if the pouch be large enough to contain gas. Sometimes the horizontal posture is necessary to fill them. This applies particularly to those projecting upwards from the duodeno jejunal flexure. Pressure on the duodeno jejunal flexure may by distending the duodenum help to fill them.

Differential Diagnosis—In most cases the nature of the condition is quite evident but at times it may be mistaken for other conditions. The

commonest error is to mistake a diverticulum of the fourth part of the duodenum for a niche on the lesser curve of the stomach. This simulation occurs only when the lesser curve of the barium filled stomach half overlaps the diverticulum and its true nature is apparent as peristalsis proceeds. Diverticula are distinguished from other shadows which may be present in the neighborhood of the duodenum—e.g. calcified gall stones or glands—by the permanence and lesser density of the latter.

Primary diverticula near the ampulla may be indistinguishable from the ampullary type and if near the first part of the duodenum it may be difficult to distinguish them from secondary diverticula. Deformity of the bulb usually present in the latter affords the clue.

Secondary Diverticula

These are found only in the first portion of the duodenum have a complete muscular coat and are secondary to an adjacent lesion most commonly a duodenal ulcer. They may be either pulsion or traction and are rare compared with the primary variety.

Of the pulsion type the most common is that found opposite ulcer scars. The scarring causes constrictions and the shallow pouch so formed gradually becomes deeper by continued pressure. The neck of the pouch is usually wide.

Hillie has described three cases of ulcer diverticulum in which a dense fibrous sac was formed the bowel wall having been destroyed by ulceration.

The traction group of secondary diverticula result usually from the drag of adhesions between the duodenum and gall bladder lesser curve or appendix.

X RAY FEATURES—These diverticula tend to be larger than the primary type and are often irregular in shape and wide-necked. They are associated with some deformity of the duodenum from either scarring or ulceration. Sometimes these diverticula are large and would be more accurately described as pouchings of the duodenal wall with no appreciable neck. These larger more open pouches merge with the group of cases described under the term "looped duodenum".



FIG. 100. Diverticulum of the second part of the duodenum.

THE SYMPTOMATOLOGY of secondary diverticula is that of the primary lesion but occasionally they are associated with dyspeptic symptoms even when the primary causative ulceration has disappeared.

Ampullary Diverticula

Two types of these occur:

(1) When the papilla of the bile and pancreatic ducts opens into the fundus of a small duodenal pouch. This has no clinical significance. Its only radio-



Fig. 101. Diverticulum of the second portion of the duodenum. (a) 6 hours after a barium meal. (b) On refilling the stomach.

logical significance is that it cannot be distinguished from a periampullary diverticulum.

(2) Dilatation of the ampulla of Vater itself. The cause be it congenital or acquired is uncertain. Possibly some develop as a result of impaction of a gall stone. It is of importance clinically according to Case who states that it is associated in 70 per cent of cases with chronic pancreatitis.

RADIOLOGICALLY these appear as small round or oval barium filled pouches a few millimetres in diameter in the second portion of the duodenum at the site of the ampulla.

The ampulla of Vater may however fill with an opaque medium apart from either of the above two abnormalities. This is a not infrequent occurrence and without significance except in the matter of differential diagnosis.

It is seen radiologically as a small fleck medial to the mid point of the second portion of the duodenum, mobile, painless on pressure, and showing no fluid levels such as are seen in true diverticula.

CHRONIC DUODENAL ILEUS

Willie was the first to draw attention in this country to this condition as a clinical entity. Simultaneously it had been recognised by American and French observers. As described by Willie, its essential feature is a partial obstruction of the third part of the duodenum by pressure on it of the superior mesenteric vessels and the mesenteric root in which they are contained and Beck have drawn up a wider classification, on which the following is based:

- (1) Non-obstructive Ileus Megaduodenum
- (2) Obstructive Ileus

INTRINSIC From neoplasm, duodenitis, congenital atresia, diverticula.

EXTRINSIC Chronic arterio mesenteric obstruction, adhesions, jejunal enosis after gastrojejunostomy, pressure from extrinsic tumours of glands, intracolic abnormalities such as tumour, abscess or annular pancreatic head surrounding the duodenum.

Megaduodenum

This type is easily recognised radiographically, as it is not dependent on organic obstruction. Two theories are held regarding its aetiology—that it is a congenital abnormality, and alternatively that it is the result of a neuritis associated with incoordination and allied to Hirschsprung's disease. Proof of either theory is, so far, wanting. Patients exhibiting this condition are of hyposthenic type, and the duodenal cap is involved in the dilatation. In the erect position barium tends to collect in a pool in the dependent portion of the duodenum and duodenal bulb. Examination in the supine or prone position serves to outline the duodenum more fully, and also shows free passage of the contrast medium into the jejunum. The mucosal pattern of the duodenum is unaltered in this condition.

Obstructive Ileus from Intrinsic Lesions

These lesions are rare, some of them extremely so. In addition to the obstructive dilatation of the duodenum, there may be present in the case of one of them the radiographic evidence of the causative lesion.

Obstructive Ileus due to Extrinsic Pressure

Chief amongst these are arterio mesenteric occlusion and jejunal obstruction after gastrojejunostomy.

In the first of these, *chronic arterio mesenteric occlusion*, the essential factor

in the etiology is pressure of the superior mesenteric vessels and the mesenteric root.

Any factor which lessens the angle between the superior mesenteric artery and the aorta will tend towards duodenal occlusion. A congenital abnormality might do so and this is doubtless the explanation of those cases occurring in childhood with gastromegaly and megaduodenum up to the point of crossing of the vessels.

As the condition usually develops in adult life another factor must take effect—some traction on the mesentery—and one which will account for the intermittent nature of the symptoms. Enteroptosis provides this effect in



FIG. 10.—Two phases in a serial radiogram of a case of arteromesenteric duodenal ileus (proved at operation).

two ways—by the drag of the small intestine on the mesentery and by similar traction of the right colon on the mesentery when the colon is unduly mobile and dependent and the caecum ptosed into the pelvis. In rare cases an abnormal right colic artery is the offending vessel descending almost vertically across the duodenum as described by Gregoire.

The symptomatology is suggestive—a history of bilious attacks in a viscerototic type of female patient gradually getting worse after the age of 30—epigastric discomfort and flatulence following all meals and relieved by lying down or especially the genupectoral position. The bilious attacks typically consist of a day of headache, nausea and epigastric discomfort followed by vomiting at first clear and later bilious. Following this the symptoms are relieved. Constipation usually ushers in the attacks which tend to recur every month or so.

Radiographic Features—All degrees between an apparently normal duodenum and gross dilatation may be found. The gross degrees are rare but minor degrees are not uncommon and may require no treatment. In mild cases there may be no abnormality to be seen in the duodenum between the attacks. In an established case a typical picture is presented (Figs. 102, 103). The duodenum is dilated, may be grossly so. The valvulae conniventes persist but are thin and widely spaced in gross cases. This is due to the stretching of the mucosa between the valvulae and is not seen in congenital megaduodenum.



FIG. 103.—Arterio mesenteric duodenal stenosis—supine view.

Screen examination presents a typical appearance. The duodenal peristalsis is active and often writhing and reverse peristalsis commonly present gives a to and fro or pendulum movement to the duodenal contents which is quite characteristic of obstruction. Often the appearance is curiously like that of a reversing cog wheel.

On tracing the duodenum up to the point of obstruction it will be seen that there is no sign of annular constriction but that the bowel is flattened against the spine its lumen being reduced to a vertical slit. A further characteristic feature is the appearance of the mucosal pattern. Frequently in

these cases the normal cross hatching of the plicæ changes at the point of obstruction to longitudinally disposed rugæ. Owing to the intermittent nature of the dilatation in many of the cases it is of importance to examine the patient radiographically at the beginning of the attack. If seen at that stage the radiographic picture is definite and characteristic.

OBSTRUCTION FROM PERIDUODENITIS—This produces a mild degree of ileus since the obstruction is not gross. It presents certain radiological features which may help to distinguish it from the arterio mesenteric variety. The obstruction is more constant. Two manoeuvres are available to test the constancy or inconstancy of an ileus. *Hayes* method consists in attempting to raise the mesentery by manual palpation with the patient in the erect position and so relieving the obstructive pressure on the duodenum. It is a difficult and uncertain procedure and its aim is much more surely accomplished by placing the patient in the knee elbow position. If it is too difficult to screen the patient in this position a compromise may be adopted—that of the ventral position—with cushions so arranged under the pelvis as to prevent direct pressure on the abdomen.

These procedures will successful relieve the obstruction in arterio mesenteric ileus but not in that due to periduodenitis. Posture of this type is also a useful therapeutic measure in arterio mesenteric ileus and the relief from symptoms so obtained forms a therapeutic differential test.

OBSTRUCTION FROM ADHESIONS AND BANDS congenital and acquired form a not uncommon group. The radiographic appearance may be very varied depending on the disposition of the bands but they are less likely to be relieved by posture than the true arterio mesenteric variety.

OBSTRUCTION FROM PRESSURE OF EXTRINSIC TUMOURS—Carcinoma of the head of the pancreas may obstruct the distal portion of the duodenum so as to produce ileus but more commonly the whole duodenal loop is stretched and flattened round the enlarged pancreatic head. In a radiogram after a barium meal the stomach shows dilatation and stasis and the duodenum takes the form of a thin streak in rather a wide circle. A cyst or abscess of the pancreatic head produces a similar appearance.

Kellogg has collected from the literature twenty five cases of duodenal obstruction from annular pancreas the head of the pancreas being in the form of a ring surrounding the duodenum. In the majority of these the proximal duodenum was dilated.

ILEUS FOLLOWING GASTRO JEJUNOSTOMY—This in the writer's experience is the commonest type of chronic duodenal ileus. It may occur in several of the stenotic sequelæ of that operation but it is most marked when the stoma and adjacent jejunum are stenosed and the pylorus patent. If marked the ileus may be gross. In contradistinction to the arterio mesenteric type of ileus the dilatation involves the whole of the duodenum and the proximal limb of the jejunal anastomotic loop.

Duodenal Ileus in Children

The condition is rare in children and falls into two classes

(1) The acute type from gross obstruction—either arterio mesenteric or atresic. These are not usually seen in an X-ray department. Schinz and R. H. Bolling have each reported a case of congenital atresia in which the proximal duodenum reached a large size and formed a bulbous sac as large as the stomach. In the latter's case this was seen radiographically eight days after birth.

(2) The chronic type getting worse as ptosis develops. Gastromegaly develops more markedly than in adults and may in the radiographic examination mask the duodenal ileus. Miller and Courtney Gage have reported a series of this type.

Duval reports a case of cyclical vomiting of infancy in which a typical arterio mesenteric ileus was found with violent ta and fro peristalsis. The attacks were at once relieved by the ventral posture.

MEGABULBUS

The duodenal bulb may be large from several causes.

The congenital type is rare. It is recognised by the considerable disparity between its size and that of the antrum and by the entire absence of obstructive abnormality distal to it (Fig. 104).

A milder degree of dilatation is often present in hypothyroid individuals and is reasonably accounted as being due to diminished tone.

A third type is that due to some obstruction in the duodenum distal to it such as scarring from ulcer at the apex of the bulb or stenosis of the duodenum at the junction of the first and second portions by cholecystic adhesions or periduodenitis. The radiological differentiation of these types depends on the recognition of the obstructive lesion or the hypotonia or their absence in the case of the congenital variety.

MICROBULBUS

The duodenal bulb may be anatomically small in which case it is regular in contour or from cicatrical contracture when it is irregular or finally from general spasticity when it is uniformly spiky.



FIG. 104.—*Megabulbus*, or jumbo-major bulb.
The actual size was 9½ inches across.

DUODENUM INVERSUM

This term has been used to describe a reversed disposition of the duodenal loop the food travelling through the duodenum in a clockwise circle instead of the normal. Two varieties are described a mobile and a fixed.

Mobile Inversion—This abnormality is dependent on the presence of a meso duodenum which allows the first and second portions to sag down and



FIG. 10a. Mobile type of Duodenum inversum or looped duodenum.

so reverse the direction of the duodenal loop. It is said to be associated with a hypotonia.

Allied to this is the condition described as *looped duodenum* in which the first portion of the duodenum is dilated and possesses a mesentery (Fig. 10a). This mesentery is short or non-existent at the pylorus and bulb. As a result when a barium cream passes through the pylorus with the patient erect it spills down into the dependent loop and then because of the dilatation tends to form a pool. This empties into the second portion by overflow. The drag of this loop often causes a flattening and distortion of the bulb.

In the supine and prone positions the looping is less evident, or the loop may be entirely restored to the normal position

In the fixed form the inversion is complete, and only the first portion of the duodenum is mobile *Sandera* describes the radiographic features of seven cases

MORPHOLOGICALLY the inversion is complete, and the bulb is kinked downwards Variation in posture reveals that only the first part is mobile The position of the remainder is constant The pylorus and duodeno jejunal flexure are situated normally, to the left of the midline The stomach is of the ptosed hypotonic type

The following functional changes are seen a tendency to to and fro or pendulum movement of the contents of the loop, and stasis therein In a case illustrated by this observer the loop showed a mild ileus

CLINICALLY symptoms may be present, but whether caused by the abnormality or by an associated state, such as *Glenard's disease*, is uncertain Epigastric discomfort after food a feeling of distension, nausea, and sometimes actual pain have been noted, but they do not constitute a characteristic symptom complex

SITUS INVERSUS PARTIALIS, COMMUNE MESENTERIUM

In this congenital abnormality, described in detail in the section on the colon, the third part of the duodenum does not cross the midline, and there is no duodeno jejunal flexure underneath the superior mesenteric artery The third and fourth parts of the duodenum descend to the right flank to join the jejunum, which with the ileum occupies that part of the abdomen

BENIGN TUMOURS OF THE DUODENUM

These are rare, but not so much so as carcinoma The commonest varieties met with are myoma adenoma, fibroma and lipoma As they increase in size they may cause duodenal obstruction and give the radiographic picture of that complication They tend to become pedunculated, and then produce a mobile filling defect in the duodenum

When large and pedunculated they may cause duodenal intussusception Of a series of ten cases of intussusception collected by *Kellogg*, three were diagnosed radiographically as simple stenosis, malignant stenosis, and adhesions respectively The last case is reported by him in detail—a fibroma attached to the duodenal wall near the pylorus and the tumour, pylorus and duodenum invaginated into the jejunum The radiogram showed the pylorus invaginated into the duodenum, and a filling defect from the tumour invaginated into the jejunum.

CARCINOMA OF THE DUODENUM

This is a rare disease being reported to represent 2 per cent of all primary malignant growths of the intestine. It is commonest in the second portion. According to Rolleston 60 per cent of cases occur in that site.

Pathologically there are two types—cylindrical celled tending to produce an annular constriction and spheroidal-celled. The latter type forms a flat plaque or a deep fungating ulcer.

The Radiological Features vary according to the pathological type and the site.

(1) SUPRA AMPULLARY.—The symptoms are those of pyloric carcinoma and radiographically the condition is mistaken for a duodenal ulcer if the pyloric canal is intact. If the pyloric ring is involved in the growth pyloric carcinoma or pyloro-duodenal ulcer are the conditions for which it is liable to be mistaken.

(2) AMPULLARY.—Intermittent jaundice is an early feature. A barium meal will show a filling defect and/or a duodenal ileus from obstruction by the lesion.

(3) INFRA AMPULLARY.—In these cases there is a considerable tendency to obstructive ileus. Clinically vomiting is a feature the vomit containing bile and pancreatic ferments.

Radiographically a duodenal ileus is evident and possibly a filling defect from the obstructing growth.

THE DUODENUM IN ENLARGEMENTS OF THE HEAD OF THE PANCREAS

The duodenum shows a typical appearance in these enlargements whatever the cause be it carcinoma, sarcoma, cyst or abscess. This consists in a widening of the duodenal circle and a flattening and compression of its lumen. As the duodenum is wrapped round three quarters of the head of the pancreas obviously any enlargement of the latter will tend to spread out the duodenal arc and to stretch and flatten it as a tube. Gastric stasis is a common sequela. With considerable enlargements the pyloric antrum may be raised and the duodeno jejunal flexure depressed. The commonest type of enlargement is carcinoma in which condition the diagnosis is usually settled by obstructive jaundice.

CHAPTER VIII

THE STOMACH AND DUODENUM AFTER OPERATION

X RAY EXAMINATION of the stomach or duodenum which has been the seat of surgical interference frequently presents a problem of great difficulty.

In the case of the intact stomach the examination is made easy by the possibility of filling it out to its normal contour. As a rule however with the stomach after operation this is not possible and a wide variety of appearances may present themselves in the absence of any pathological condition. It is the difficulty of disentangling these normal variations from the pathological which constitutes the problem.

TECHNIQUE

Because of the above consideration the radiographic technique must be modified in some respects. Screen examination is even more important than in the intact stomach and the demonstration of the mucosal relief pattern is of greater value.

The technique must be varied according to the precise operation performed and it is most desirable to have this information before commencing the examination.

From a radiographic point of view these cases fall into broad classes those in which sphincteric control of gastric evacuation has been abolished and those in which it has been retained. Some operations fall between these two groups as follows:

(1) SPHINCTERIC CONTROL RETAINED

Simple excision or cauterisation of a gastric ulcer

Wedge resection

Sleeve resection

Gastro gastrostomy

Duodenal jejunostomy

(2) SPHINCTERIC CONTROL PARTLY RETAINED

Pyloroplasty

Schoemaker's operation

Billroth I

Although in all these the muscular pyloric sphincter is either cut or removed yet enough control of efflux is exhibited by the stomach to warrant the above term in classification.

(3) SPHINCTERIC CONTROL ABOLISHED

Gastro jejunostomy (Only when abnormal contracture of the stoma has taken place, is there any degree of control)

Billroth II

Polya and its modifications

Funney's pyloroplasty

In THE FIRST GROUP, with retention of sphincteric control, the technique should follow that described for the intact stomach. Special attention should, however, be paid to the relief pattern, both under the screen and in serial radiograms. The erect, supine, and prone positions are all of value, and the most suitable for taking radiograms will be determined by the fluoroscopic appearances.

In THE SECOND GROUP, again, where partial control has been established the normal technique may suffice, but means should be at hand to control the gastric efflux, should this prove to be too rapid to allow satisfactory and complete filling of the stomach. Such means are indicated in the succeeding paragraphs.

IT IS IN THE THIRD GROUP, with abolition of sphincteric control, that most difficulty occurs. A wide communication exists between the lower part of the stomach and the small intestine, and the gastric contents are rapidly poured out into the jejunum. It is impossible to distend the stomach, or stump of the stomach in gastrectomy, unless the efferent jejunal loop be occluded by pressure. This can be done by hand temporarily under the screen but this immobilizes the palpating hand, and cannot be kept up indefinitely. Some form of mechanical compressor or truss is much to be preferred. A well known type is the Chaoul compressor. In this, a metal ring, 5 inches in diameter, supports a rubber bag which can be inflated to a hemisphere. It is strapped to the patient's abdomen by an attached broad webbing band and buckle. Pressure on the required area is induced and maintained by the inward bulge of the bag. The objections to it are the difficulty of precise adjustment and the shadow of the metal ring.

Berg's pressure cone and serial radiographic apparatus, although designed primarily to study the relief mucosal pattern of stomach and duodenum will serve to control the stoma of a gastro jejunostomy. Its disadvantage for the latter is the small aperture it possesses, limiting the fluoroscopic and radiographic field.

The writer has designed an adjustable truss which answers the latter purpose—control of the efferent loop—satisfactorily. It consists of two portions—a leather covered spring band similar to that of an ordinary hernia truss and an adjustable compression pad. Three or more spring bands are necessary, to fit varying sizes of patients. The adjustable pad comprises a base slotted for the reception of one end of the appropriate spring band, an arm hinged on this base giving, by means of a small thumbscrew and worn gear, an anterior and

posterior angulation and a leather padded aluminum pad. The arm is slotted throughout its length and the pad can be adjusted along its length by a butterfly nut. The hinged arm has an upward bend so that the compression pad is above the level of the spring band when fitted to the patient. This avoids obscuration of the field under examination by the shadow of the spring. Reference to the diagram will indicate the details of the truss (Fig. 106).

The technique for each individual case will vary according to circumstances but that which the writer uses as a basis is as follows:

The examination is commenced in the erect position, and under fluoroscopic control the

patient drinks one mouthful of the opaque cream. This gives a preliminary screen survey of the relief pattern of the stomach, the stoma and the efferent loop after which a radiogram is taken. The truss is then fitted with the spring band just below the iliac crests and the pad over the efferent loop. The patient then drinks a few more mouthfuls and the pressure of the pad is increased by turning the worm nut till obstruction of the loop is obtained. Sufficient of the meal is then drunk to distend the stomach.

Antero posterior serial and left lateral radiograms are then taken and the compressor removed. Removal of the latter is a matter of a few seconds. The rate of emptying of the stomach is then noted fluoroscopically, attention being paid to any tender points over the stomach, duodenum and stoma. The degree of jejunal overloading if any should be noted.

In a few minutes the stomach will as a rule have largely emptied itself and enough of the cream will remain therein to permit a further observance of the mucosal relief pattern in the prone and supine positions. Radiograms may be taken in these positions if necessary.

The patient should again be screened half or one hour later to determine the amount of residue in the stomach.

Such is the average technique required in these Group III cases but the study of each case should be individual and no cast iron routine should be adopted in the technique.

Before considering the normal and pathological appearances after operation it is desirable briefly to outline the nature of each. Some of the operations described below are but rarely performed and still less frequently seen in an X-ray department. Others such as posterior gastro-jejunostomy and partial

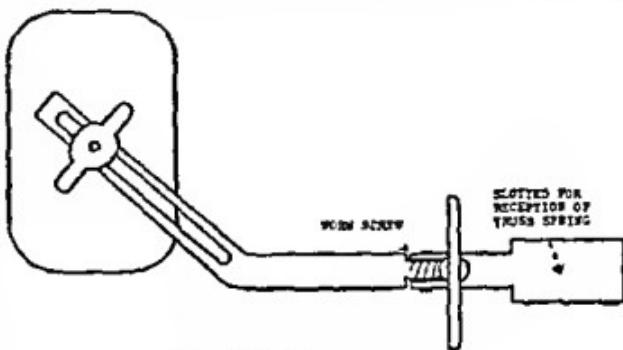


FIG. 106.—Truss compressor

gastrectomy are *à la mode* and such patients are frequently referred for X-ray investigation.

OPERATIONS RETAINING SPHINCTERIC CONTROL

Simple Excision or Cauterisation of a lesser curve ulcer The operation requires no description. It is rarely performed now. The radiographic appearances are shortening of the lesser curve, puckering at the site of operation and local disturbance of the longitudinal rugæ in the relief pattern. (The operation is usually combined with posterior gastrojejunostomy—Balfour's operation.)

Wedge Resection of the Lesser Curve—This is also out of fashion because of the tendency to recurrence. The radiographic appearances above are accentuated. Hour glass stomach is said to occur frequently after this operation. The resection on the lesser curve causes scarring and contracture on that side of the stomach and the greater curve may show a spastic incisura for a time accentuating the biloculation.

Sleeve Resection—This operation consists of segmental resection of the lesion bearing area, usually in the middle portion of the stomach, with end to end anastomosis. It is rarely performed now.

A certain amount of deformity may occur at the suture line owing to disparity in the sizes of the anastomosed ends. Some contracture of the marnastomosis usually takes place and shows radiographically as a notching of both curvatures at the site of marnastomosis. This commonly gives an hour glass appearance.

This contracture does not necessarily mean that the operation has been unsuccessful. It is compatible with a satisfactory physiological result and should not be regarded as of serious importance unless an ulcer crater is also visible in the region of the lesser curve.

The mucosal relief pattern is disturbed at the suture line. According to Kerley a temporary pyloric insufficiency with duodenal dumping results from the section of the nerves.

Gastro gastrostomy an anastomosis performed of yore between the two sacs of an organic hour glass stomach. It has been entirely superseded. The radiographic appearances would be those of a double channel in the stomach with considerable irregularity. Dural reports several such cases.

Duodeno jejunostomy—This is the operation of choice in chronic duodenal ileus involving the whole duodenum. The duodenum is mobilised brought through the transverse mesocolon and anastomosed laterally to the jejunum a short distance below the duodeno jejunum flexure (Fig. 107).

On comparison with radiograms taken before the operation the duodenal dilatation will be seen to have diminished or disappeared and the opaque medium to pass through the stoma into the jejunum (Fig. 108). The stoma may be hidden in the erect position by the stomach if the latter be ptosed and dilated. If so the supine position will bring it into view.

Cholecysto-gastrostomy — This operation is performed for complete obstruction or destruction of the common bile duct, and consists in anastomosing the fundus of the gall bladder to the anterior surface of the pyloric antrum. The radiographic appearance with a barium meal is quite typical. The gall bladder fills with barium, and in the erect position the upper part of the gall bladder contains an air pocket above the barium. The cystic and hepatic ducts may also fill, and are prone to do so, since they are usually to some extent dilated as a result of the obstructive lesion for which the operation was performed.

Cholecysto-duodenostomy — In this a similar radiographic appearance is seen, save that the anastomosis is between the fundus of the gall bladder and the mobilised second portion of the duodenum. The connections of the viscera are then the same as obtains in calculous cholecysto-duodenal fistula.

OPERATIONS RETAINING PARTIAL SPHINCTERIC CONTROL

Simple Pyloroplasty — This consists of a longitudinal incision of the pyloric canal, in cases of simple pyloric stenosis the incision being sutured transversely (Fig. 109). It is rarely if ever performed now gastro-enterostomy or Finney's operation being used in its stead. The radiographic contours of the pylorus and duodenal bulb are grossly distorted by this

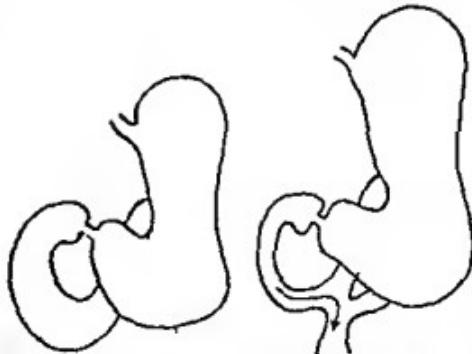


FIG. 107.—Duodeno-jejunostomy.



FIG. 108.—Normal appearance after duodeno-jejunostomy for arterio-mesenteric duodenal ulcer.



FIG. 109.—Simple pyloroplasty.

operation and unless previous information as to the operation were available it would be mistaken for pyloro duodenal ulceration or scarring.

Billroth I (known in France as *Pean's* operation)—This is in essence a partial gastrectomy with end to end anastomosis of the cut duodenum to the lower portion of the gastric stump (Fig 110). The upper portion of the gastric cut end is closed by sutures. It is technically difficult and leaking from the stoma is apt to occur. It is rarely performed now. Radiographically the stomach is seen to be truncated and the gastric contents to pass from its most dependent portion into the duodenum. The stomach is dragged to a varying extent to the left. The degree of control of efflux is dependent on the amount of contracture at the anastomosis.

Kocher's Operation is similar to the Billroth I except that in it the gastric stump is closed and the cut end of the duodenum is anastomosed terminally with the posterior surface of the stomach. *Cuneo* illustrates an example in which the radiographic appearance is that of a conical gastric stump with the duodenum joined to its end. The appearance is substantially the same as in the Billroth I. Gastric evacuation was rapid in this case.

Schoemaker's Operation—This is a partial gastrectomy leaving a long tongue of the greater curve to allow of an end to-end anastomosis with the duodenum. The diagram indicates the type of resection.

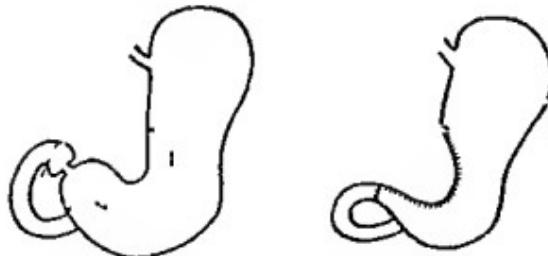


FIG 111—Schoemaker's operation

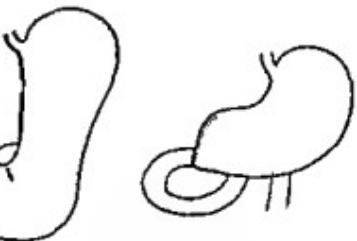


FIG 110—Billroth I partial gastrectomy

It is a modification of the Billroth I designed to overcome the technical difficulties of the latter. It was first described by *Schoemaker* of The Hague in 1921 and an excellent account of sixty eight cases has been published by *Morley* and *Roberts* (Fig. 111).

The X-ray feature of note in cases after a Schoemaker operation is the gradual *restitutio ad integrum* in the gastric contour. The food passes more slowly out of the stomach than in a Polya or Billroth II but more rapidly than in the normal stomach. After six months there may be surprisingly little deformity of the lesser curve, a rather wide pyloric ring appears and the first portion of the duodenum may develop an almost normal bulb. The pyloric antrum is naturally short and rather narrow in calibre.

GROUP WITH ABOLISHED SPHINCTERIC CONTROL

This group comprises the majority of post-operative cases referred for X-ray examination, including as it does gastrojejunostomy and the popular varieties of gastrectomy. Incidentally it is the most difficult group to examine radiographically.

POSTERIOR GASTRO-JEJUNOSTOMY

This is the operation of choice for simple pyloric obstruction and duodenal ulcer, and is probably performed more often than all the other gastric operations together. The essence of it is to form a wide anastomotic opening between the jejunum as close to the duodeno-jejunal flexure as possible and the posterior wall of the stomach (Fig. 112). The anastomosis must of necessity be made through the posterior layer of the lesser sac. The pylorus is sometimes occluded, thus occlusion is often designed to be temporary, and by suitable choice of sutures the pylorus will become patent again six months after the operation.

The objects of the operation are to provide free drainage of the stomach to allow alkaline regurgitation from the jejunum and to prevent the passage of acid gastric contents over the pyloric or duodenal ulcer.

There are certain surgical desiderata to be observed in the planning of the operation:



FIG. 112.—Posterior gastrojejunostomy

(1) The stoma when made should be $2\frac{1}{2}$ – $3\frac{1}{2}$ inches in length. This large opening is chosen to allow for the considerable contraction which takes place after the operation.

(2) The long axis of the stoma should be roughly vertical. It may incline either to the right or left without detriment. The usual inclination is from the right shoulder to the left hip, for reasons of technical facility.

(3) The lower end of the stoma should be close to the most dependent portion of the greater curve, to prevent stasis in the stomach below the level of the stoma. This latter, however, occurs only if the stoma be placed very high.

(4) No more of the jejunum should be left between the duodeno-jejunal flexure and the stoma than will allow an easy sweep downwards on the part of the jejunum between these points. Too little "cloth" will produce dragging on the flexure, whilst a redundant loop may promote stasis in the proximal limb.

NORMAL RADIOLOGICAL APPEARANCES

In the erect position the prominent feature is the immediate passage of the opaque medium into the jejunum. This occurs as soon as the patient swallows a mouthful or so. No more should be given in the first instance, as the initial study of the relief pattern of the stomach, stoma, and jejunum is important.

If then the patient takes the remainder of a 12-14 oz barium meal some fleeting complete filling of the stomach may take place, but more commonly an irregular partial filling only is achieved the barium pouring into the efferent loop of the jejunum in a steady stream (Fig 113). The greater curve above the stoma is frequently indented by the mucosal folds resulting from the muscular contractility of the stomach. During this stage the stoma itself is hidden in the antero posterior view.



FIG. 113.—Normal poster or gastro jejunost my immediately after the meal.

cream passes through the pylorus and duodenum but even then the pyloric antrum tends to be conical and lacks its normal rounded contours. If the pylorus has been occluded the filling of the pyloric antrum is very poor indeed.

The stoma may be seen in profile in a lateral view but for technical reasons it may be difficult to obtain a sharp radiogram of it in this position.

The efferent jejunal loop and the upper few coils of jejunum are usually somewhat distended with barium and a mild permanent dilatation of the upper jejunum is normal. It may be considerable. The feathery appearance resulting from the valvulae conniventes persists but to a less extent than in the normal as a result of this dilatation.

As a rule little or none of the meal passes into the afferent loop via the stoma with the patient in the erect position. Any barium present in it and in the duodenum will usually have found its way through the pylorus.

The rate of emptying is remarkably rapid in the writer's experience. Various authorities have given the time for complete emptying as one to two

hours. In the writer's experience the time for complete emptying is about 1½ hours.

hours, and even more. These figures may be true if by "emptying" is meant the complete evacuation of every trace of barium from the stomach, but not if the main mass of barium is referred to. The main bulk of the opaque meal may have passed out into the jejunum in ten to fifteen minutes, and yet traces of barium remain entangled in the mucosal folds for an hour or two (especially in the folds of the pyloric antrum). Disregarding these entangled residues, the stomach is empty in from seven to thirty minutes, if the stoma be of average size. With a large stoma these limits are shortened, and with a small one they are increased.

Ducal and his co-workers state that although there may be rapid emptying for a time after the operation eventually, if the operation is successful, the stoma acquires some measure of sphincteric control, and the rates of gastric evacuation are only a little less than those of the average intact stomach.

There is no doubt that the rate of evacuation in gastrojejunostomy gradually slows down with the passage of months or years. To account for this by postulating a true sphincteric action is to attribute to the stomach a remarkable metaplastic power, that of growing a circular ring of muscle fibres round a wound in its wall, and developing a reflex nervous arc to control it. This seems scarcely within the bounds of improbable possibility. A more reasonable explanation would be the gradual contraction of the circular submucous scar resulting from the incisions, with consequent narrowing of the stoma.

The more marked degrees of slowing of the gastric evacuation—up to several hours—are in most cases due to post-ulcerative stenosis of the stoma.

The rate of emptying of the stomach is modified by posture. In the supine position a pool in the fundus may remain for a time, being there below the level of the stoma. No lengthy stasis occurs however, because of the contractile tonus of the stomach.

As the stomach empties its contents, the mucosal pattern of and round the stoma again makes its appearance, and may again be studied fluoroscopically and in radiograms.

Tenderness on pressure over the stoma and elsewhere is an important diagnostic feature and careful search for such tender points should always be made.

If the stomach before the operation was grossly dilated and atonic, and its muscle coats too atrophied to be restored to the normal, the radiographic picture after gastrojejunostomy will be somewhat modified. Some dilatation will remain, the indentations of the greater curve will be less and there will be a tendency to pool formation in the pyloric antrum below the stoma. The main mass of the barium cream will, however, pass rapidly into the jejunum.

Pressure Control of the Efferent Loop

It is obvious from the normal appearances, without control, that the demonstration of recurrent duodenal and pyloric ulcer, and to a less degree lesser-curve ulcer, may be difficult on account of incomplete filling of the stomach.

Efficient obstruction of this loop enables the contrast medium to be dammed back in the stomach and a study of these portions to be made. Using an apparatus such as is described above, the lesser curve can be examined in its entirety. The prepyloric region is sometimes filled to its normal contours, but more frequently remains to some degree contracted and conical. If the pyloric canal be not obstructed or occluded, the meal can be forced through it into the duodenal bulb. It is of importance here to know beforehand whether the pylorus was occluded at the operation or whether it was already stenosed. The duodenal bulb does not usually fill out to normal contours, partly because it is difficult to force a sufficiently large amount of barium through the pylorus at a time and partly because some scarring of the bulb may persist after the healing of a duodenal ulcer.

THE COMPLICATIONS OF POSTERIOR GASTRO-JEJUNOSTOMY

Tabulated below are the normal and abnormal results in 150 consecutive barium meal examinations of posterior gastro-jejunostomy. They are drawn from the X-ray departments of two London hospitals and private practice, and represent cases operated on by many different surgeons. That is to say, they do not represent the surgery of those two hospitals, but rather an average sample from most of the surgical centres of London and some of the provinces.

POSTERIOR GASTRO JEJUNOSTOMY 150 CASES

Normal	23
Dumping stoma	12
Inflammatory sequelæ	
Gastritis	4
Gastro-jejunitis	19
Jejunitis	17
	— 40
Ulcerative sequelæ	
Recurrent duodenal	25
Recurrent lesser curve	16
Jejunal	11
Recurrent posterior wall	6
Recurrent pyloric	2
Stomal	3
	— 63
Gastro-entero-coecal fistula	3
Stenotic sequelæ	
Stenosis of stoma	22
Obstruction of stoma	9
Stenosis of efferent limb	5
Stenosis of afferent limb	3
Duodenal stenosis	6
Jejunal stenosis	2
Contracture of pyloric antrum	2
Pyloric stenosis	1
	— 53
Highly placed stoma	2
Carcinoma supervening	2
Retrograde jejunostomy intussusception	1
Total	150

The number of abnormal results found by examination exceeds considerably the total number of cases as in many cases more than one abnormality was found e.g. recurrent duodenal ulcer and jejunitis.

Verification of the abnormal results by operation has been possible in a small proportion of cases only owing to a wise reluctance on the part of surgeons to operate on these cases a second time but the more serious of the complications are only too certain radiographically. Amongst such may be mentioned recurrent ulceration and the grosser forms of stenotic sequelæ. In the milder abnormalities such as dumping stoma, slight stomal stenosis, slight gastro-jejunitis a personal factor may allow some error to creep in in differentiating the abnormal from the normal but these are of little consequence compared with the others.

Jejunal Dumping (Syn. dumping stoma, overloading of the jejunal loop)

This is a fairly common sequelæ. If the stomach be very large the flooding of the jejunum is exaggerated and the stomach may empty into it in two to three minutes. The patient experiences a dragging fullness and discomfort immediately after food and the jejunum is seen to be distended and overloaded temporarily. Dietetic indiscretions either of quality or of quantity increase the patient's discomfort. It is reasonable to explain the symptom complex on these mechanical grounds. To what extent jejunal overloading contributes to the development of jejunal ulcer is a moot point and one difficult to put to the test.

Gastritis

The presence of this condition is difficult to establish radiologically in the absence of an associated jejunitis unless it is gross in degree.

The commonest type is a peri-anastomotic haemorrhagic gastritis a condition frequently leading to stomal ulceration.

The difficulty lies in the increase in the rugæ folds which usually occurs in a successful uncomplicated gastro-jejunostomy so that unless the jejunum is also implicated this condition should be diagnosed radiographically only if there is gross increase in the size of the rugæ and marked spastic retraction on the greater curve.

Jejunitis

The barium in a normal loop of jejunum shows a feathery or granular distribution with fine subdivisions due to the valvulae conniventes. In the normal jejunum immediately distal to a gastro-jejunostomy some alteration in the appearance results from the overloading of the gut. The valvulae conniventes are still clearly seen as thin knifelike intersections in the barium mass. Jejunitis is a not uncommon sequela of gastro-jejunostomy especially in cases of marked

Efficient obstruction of this loop enables the contrast medium to be dammed back in the stomach, and a study of these portions to be made. Using an apparatus such as is described above, the lesser curve can be examined in its entirety. The prepyloric region is sometimes filled to its normal contours, but more frequently remains to some degree contracted and conical. If the pyloric canal be not obstructed or occluded the meal can be forced through it into the duodenal bulb. It is of importance here to know beforehand whether the pylorus was occluded at the operation, or whether it was already stenosed. The duodenal bulb does not usually fill out to normal contours partly because it is difficult to force a sufficiently large amount of barium through the pylorus at a time and partly because some scarring of the bulb may persist after the healing of a duodenal ulcer.

THE COMPLICATIONS OF POSTERIOR GASTRO-JEJUNOSTOMY

Tabulated below are the normal and abnormal results in 150 consecutive barium meal examinations of posterior gastro-jejunostomy. They are drawn from the X-ray departments of two London hospitals and private practice and represent cases operated on by many different surgeons. That is to say they do not represent the surgery of those two hospitals but rather an average sample from most of the surgical centres of London and some of the provinces.

POSTERIOR GASTRO-JEJUNOSTOMY 150 CASES

Normal	23
Dump of stoma	12
Inflammatory sequelae	
Gastritis	4
Gastro-jejunitis	10
Jejunitis	17
	— 40
Cicatrictive sequelae	
Recurrent duodenal	25
Recurrent lesser curve	16
Jejunal	11
Recurrent posterior wall	6
Recurrent pyloric	2
Stomal	3
	— 63
Gastro-entero-cole fistula	3
Stenotic sequelae	
Stenosis of stoma	22
Obstruction of stoma	9
Stenosis of eff rent limb	5
Stenosis of afferent limb	3
Duodenal ileus	6
Jejunal ileus	2
Contracture of pyloric antrum	5
Pyloric stenosis	1
	— 3
Hist mal placed stoma	2
Carcinoma supervening	2
Refracts to jejunogastric intussusception	1
Total	150

The number of abnormal results found by examination exceeds considerably the total number of cases, as in many cases more than one abnormality was found e.g. recurrent duodenal ulcer and jejunitis.

Verification of the abnormal results by operation has been possible in a small proportion of cases only, owing to a wise reluctance on the part of surgeons to operate on these cases a second time, but the more serious of the complications are only too certain radiographically. Amongst such may be mentioned recurrent ulceration and the grosser forms of stenotic sequelæ. In the milder abnormalities, such as dumping stoma, slight stomal stenosis, slight gastro-jejunitis a personal factor may allow some error to creep in in differentiating the abnormal from the normal, but these are of little consequence compared with the others.

Jejunal Dumping (Syn. dumping stoma—overloading of the jejunal loop)

This is a fairly common sequela. If the stoma be very large, the flooding of the jejunum is exaggerated and the stomach may empty into it in two to three minutes. The patient experiences a dragging fullness and discomfort immediately after food, and the jejunum is seen to be distended and overloaded temporarily. Dietetic indiscretions, either of quality or of quantity increase the patient's discomfort. It is reasonable to explain the symptom complex on these mechanical grounds. To what extent jejunal overloading contributes to the development of jejunal ulcer is a moot point, and one difficult to put to the test.

Gastritis

The presence of this condition is difficult to establish radiologically in the absence of an associated jejunitis, unless it is gross in degree.

The commonest type is a peri-anastomotic haemorrhagic gastritis, a condition frequently leading to stomal ulceration.

The difficulty lies in the increase in the rugæ folds which usually occurs in a successful uncomplicated gastro-jejunostomy, so that unless the jejunum is also impinged, this condition should be diagnosed radiographically only if there is gross increase in the size of the rugæ and marked spastic reaction on the greater curve.

Jejunitis

The barium in a normal loop of jejunum shows a feathery or granular distribution, with fine subdivisions due to the valvulae conniventes. In the normal jejunum immediately distal to a gastro-jejunostomy some alteration in the appearance results from the overloading of the gut. The valvulae conniventes are still clearly seen as thin knifelike intersections in the barium mass. Jejunitis is a not uncommon sequela of gastro-jejunostomy, especially in cases of marked

hyperchlorhydria. It may exist with or without gastro-jejunal or jejunal ulcer, but is an invariable accompaniment of the two latter. The radiographic appearance is typical and can be readily pictured from an appreciation of the pathological changes (Fig. 114-116). The jejunal mucosa becomes hypertrophic and oedematous and the plicae markedly thickened. The barium-filled jejunal

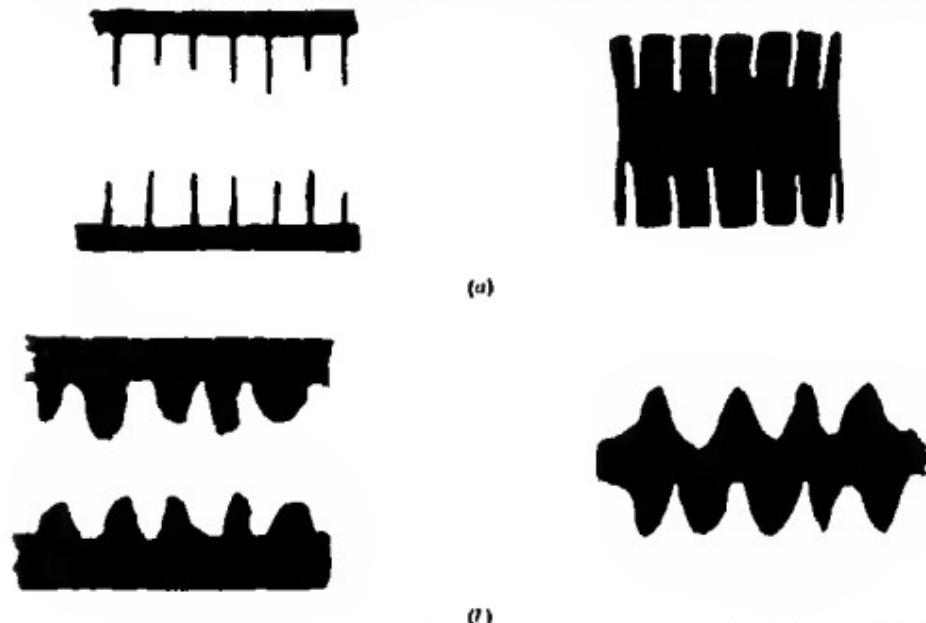


FIG. 114.—Diagram to show the wall of the jejunum and its barium-filled lumen in (a) the normal and (b) hypertrophic.

lumen as a whole is narrowed and presents instead of the normal fine tooth comb serrations a series of wide rounded or jagged indentations due to the thickened plicae. This deformity shows a constant contour in a series of pictures—an important diagnostic point. Tenderness on radioscopic palpation over it is present in the great majority of cases.

Persistent or Recurrent Peptic Ulceration

This may be gastric, pyloric, duodenal, gastro-jejunal or jejunal in site.

GASTRIC ULCER—*Jessey-curve ulcer* is as a rule easily demonstrated if the stomach be reasonably well filled. By controlling the efferent loop a niche will be made visible with greater certainty and on the greater curve a localised exaggeration of the notching which is usually present. The same applies to an ulcer on the posterior wall.

DUODENAL ULCER presents a more difficult problem, even more difficult than in the case of a duodenal ulcer which has recurred after medical treatment.



FIG. 117.—Stages in the development of gastro-jejunitis and jejunal ulcer following on posterior gastro-jejunostomy.

Note also the development of a gastric diverticulum near the cardia.

In the latter only the deformity due to scarring has to be discounted. After jejuno-stomy, however, the further disturbing factor of incomplete or non filling of the cap must be taken into account. In some cases the actual ulcer crater may be seen, but more frequently only some general deformity of the duodenal bulb is present.

If the jejunum has been satisfactorily occluded by a truss and food is passing freely through the pylorus the second disturbing factor can be excluded, and the problem becomes that already described under the section of duodenal ulcer.



FIG. 115.—Cross gastro-jejunitis following posterior gastro-jejunostomy showing the narrowed mid-jejunum with oedematous stoma.

contracture bring the anastomosis into profile in the postero anterior view, and so render visible an ulcer in this situation. If it be large it may be visible in profile in a lateral view. Owing to the normal irregularity in the contours in a healthy stoma care must be used in diagnosing an ulcer crater from a projecting rugal crevice. Further confirmatory signs may help. The most important of these is pain on pressure localised over the stoma. Another sign of value is a persistent residue in the ulcer crater after the stomach is empty. Such a residue must, however, be differentiated from flecks entangled in the mucosal folds in this region.

JEJUNAL ULCER—If this be close to the stoma, the above remarks will apply. If it occur below the level of the greater curve there is every chance of the ulcer crater being outlined at some stage of the examination.

PYLOPIC ULCER is readily demonstrated, provided opaque food can be made to pass through the pyloric canal.

GASTRO-JEJUNAL ULCER—If the stoma on the posterior wall is hidden in the postero anterior view, a stomal ulcer may show only in a relief pattern radiogram. Frequently, however, associated spasm and cicatrical

A great care must be taken not to mistake a fleck of barium entangled in the mucosa for a barium filled crater. The larger, the denser and the more persistent a residue, the more likely it is to be in an ulcer crater (Figs 117-118). As in ulcer crater elsewhere in the alimentary canal, the absence of peristalsis in the crater promotes sedimentation of barium in it and so causes a dense opacity therein. Localised tenderness to pressure of one finger over the residue is an important confirmatory sign. The valvulae conniventes seen in relief pattern converge to and are interrupted by the crater, an appearance best seen if the latter is on the anterior or posterior wall and so viewed *en face*. An associated jejunitis is almost always present, and in the absence of this great reserve should be exercised in diagnosing stomal or jejunal ulcer.

GASTRO JEJUNO COLIC FISTULA is a not uncommon complication of jejunal ulcer, resulting from perforation of the ulcer into the transverse colon. It is described in the section on the stomach (Fig 119).

Narrowing of the Stoma

The usual surgical practice nowadays is to make a wide stoma to allow for gradual contraction. If this contraction is greater than usual the rate of gastric evacuation is slowed. To what extent this narrowing and consequent slowing is disadvantageous is a matter of doubt. The wide stoma, while it achieves



FIG. 117.—Jejunitis and jejunal ulcer following posterior gastro-jejunostomy.



FIG. 118.—Gastro-jejunitis and jejunal ulcer following posterior gastro-jejunostomy.

its results so far as drainage is concerned, alters the normal physiological processes profoundly, and frequently causes jejunal overloading. Narrowing of the stomach sufficient to slow the rate of emptying of the stomach

to between one and one and a half hours is probably not undesirable but retention in the stomach up to two three or more hours should be regarded as a sequela likely to defeat the objects of the operation. In such cases the stenosis of the stoma cannot usually be demonstrated directly. In the majority of cases its presence can be deduced only by the slow rate of emptying.

Some contraction of the stoma after a year or so is a normal occurrence but the common cause of marked narrowing of the stoma is cicatrization after ulceration. This produces varying appearances according to the exact site of the stenosis. Reference



FIG. 119 Gastrojejunocolic fistula demonstrated by a barium enema as a sequel of posterior gastrojejunostomy and jejunal ulceration.

to the diagram (Fig. 120) indicates the possibilities in this respect.

No 1 Represents the normal.

No 2 Stenosis of the stoma, the pylorus and jejunal loop remaining patent. Gastric evacuation takes place as in the intact stomach, via the pylorus and duodenum. Some puckering in the region of the stoma is usually present.

No 3 Stenosis of pylorus and stoma. This results in gastric dilatation and stasis.

No. 4. Stenosis of the stoma and afferent jejunal limb. As a result of this, gastric dilatation and stasis take place, and, in addition, duodenal ileus.

No. 5. Stenosis of the efferent jejunal limb alone. The results are precisely the same as in No. 4.

No. 6. Stenosis of the afferent jejunal limb alone Gastric evacuation

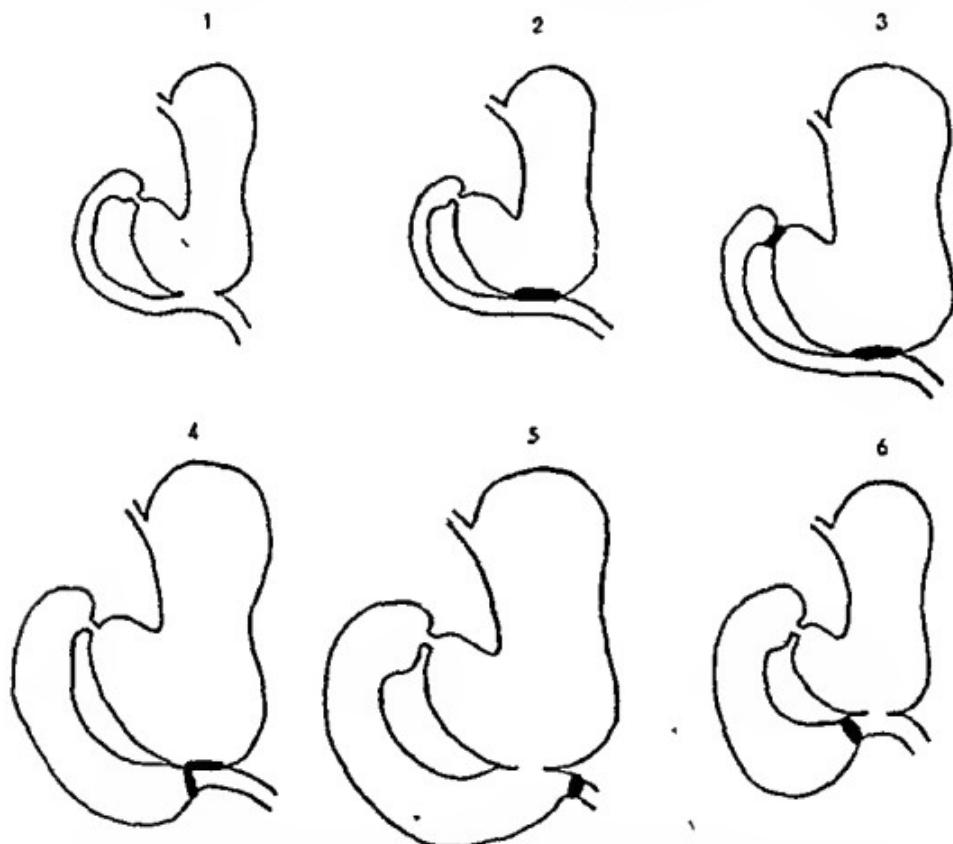


FIG. 120.—The stenotic complications of posterior gastro-jejunostomy. For the sake of clarity the stoma is shown on the margin of the stomach.

1 Normal 2 Obstruction of stoma 3 Obstruction of pylorus and stoma 4 Obstruction of stoma and afferent limb 5 Obstruction of efferent limb 6 Obstruction of afferent limb only

occurs through the stoma as in a normal gastro-jejunostomy. If any appreciable amount of food passes through the pylorus, duodenal ileus may result.

Contracture of the Pyloric Antrum

The pyloric antrum usually assumes a more or less conical shape after gastro-jejunostomy. This may be regarded as the result of disuse. Marked

contracture, narrowing the lumen down to the thickness of a lead pencil may result from spasm, interstitial fibrosis, and epigastric adhesions. In these cases it may be impossible, except by laparotomy, to exclude the presence of a supervening carcinoma particularly if anaemia, achlorhydria, and anorexia are present as they sometimes are.

Malposition of the Stoma

It is only when this is gross that serious consequences result. Minor variations in the site of the stoma are of no importance. If however the stoma is



FIG. 121.—Posterior gastrojejunostomy with obstruction of the stoma and pylorus. Gastric distension, obstructive hyperperistalsis and gastritis are characteristic features.



FIG. 122.—Old gastrojejunostomy for duodenal ulcer with stenosis of the stoma and afferent jejunal limb; recurrent duodenal ulcer, gastritis and obstructive ileus of the duodenum.

very high in the stomach satisfactory drainage may not occur and the object of the operation be not achieved. The writer has met one such case. The gastric stasis present in this case was obviated by posture when the patient lay down the stomach emptied satisfactorily.

Duodenal ileus may result in a minor degree from a high stoma especially if a visceroptosis of some degree be present. In such case if the duodenum and duodenojejunal flexure be passed below the level of the stoma the stomach may empty itself partly into the afferent jejunal loop and so into the duodenum.

This sequence of events is visible fluoroscopically. On the patient swallow-

ing a mouthful of barium, some is seen to pass into each loop of the jejunum, that going into the afferent collecting in a pool in the dependent part of the dilated duodenum. This is seen only in the erect position. The supine or prone position removes the static factor which is the essence of the abnormality.

Retrograde Jejuno-gastric Intussusception

This is a rare complication of gastrojejunostomy. It may be acute or chronic. The acute cases, of which the records of thirty-five cases have been

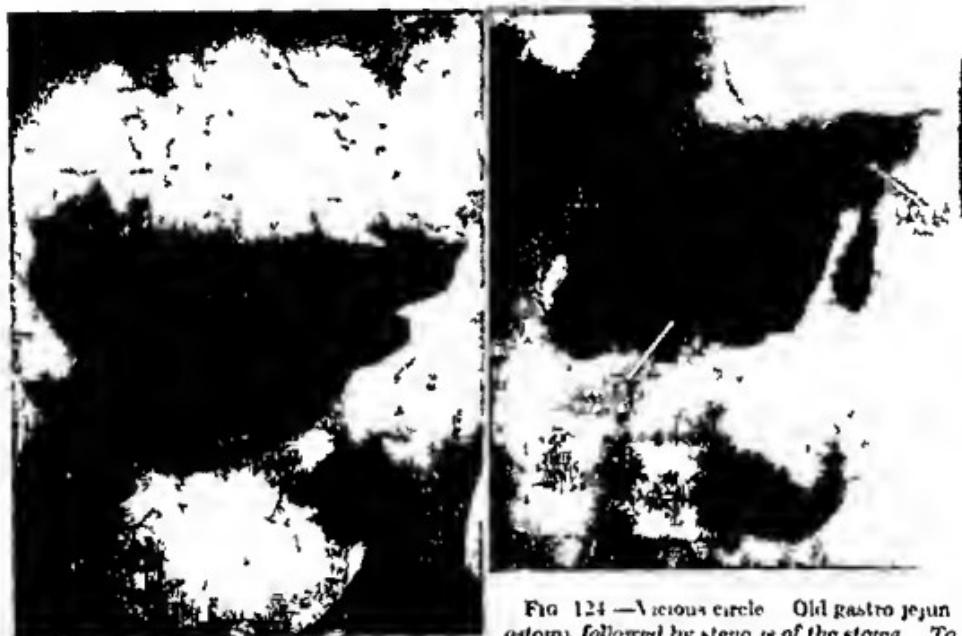


FIG. 123.—Posterior gastrojejunostomy followed by gross stenosis of the stoma and afferent limb, gastrectasis and marked duodenitis.

FIG. 124.—Various circle. Old gastrojejunostomy followed by stenosis of the stoma. To relieve this a second anastomosis was made later between the efferent limb and the upper part of the stomach. The meal passed out of the lower stoma up to the upper, and back into the stomach again.

collected by Adams are urgent surgical emergencies, precluding any radiological investigation.

Ledoux Lebard and *Garcia Calderon* note the X-ray appearances in two chronic cases. The intussusception produced a mobile rounded filling-defect and the relief pattern of the tumour showed striations due to the jejunal plicae.

The writer has seen two cases of intermittent jejuno-gastric intussusception showing these signs. In one the tumour was seen end-on, and the strike circular in disposition (Fig. 123). At operation the intussusception had



FIG. 125.—Chromic retrograde jejunogastric intussception following anterior gastrojejunostomy.

in the posterior operation except that in the anterior operation only the efferent loop should fill but frequently food also passes into the afferent loop. When this occurs to excess a vicious circle is established and the dilated overloaded proximal loop is at once apparent radiographically. Jejunojejunostomy completely relieves the condition but short circuits the alkaline duodenal juice from the stoma and so promotes the formation of anastomotic and jejunal ulcer.

The other untoward sequelæ of anterior gastrojejunostomy are similar to those in the posterior method.

Finney's Pyloroplasty

This operation is not much used in this country. It is performed in cases of pyloric and juxta-pyloric duodenal

reduced itself and only a dilated jejunum was found. The second has not been operated upon.

Anterior Gastrojejunostomy

In this a long loop of jejunum is brought up in front of the transverse colon and anastomosed to the anterior gastric wall (Fig. 126). It is performed *faute de mieux* when a gastro-enterostomy is essential and it is technically impossible to adopt the posterior method. The stoma is made as near as possible to the pylorus and greater curve and its axis should run from above downward and to the right. Because of the serious risk of stasis in the long afferent loop—about 16 inches in length as a rule—an additional jejunojejunostomy is frequently made between the two loops.

The X-ray appearances in anterior gastrojejunostomy are substantially the same as those

in the lateral view the stoma and jejunal loop are visible anterior to the stomach and two jejunal limbs afferent and efferent are often outlined below the stomach. If



FIG. 126.—Anterior gastrojejunostomy.

ulcer. The second portion of the duodenum is mobilised and anastomosed with the anterior wall of the stomach, close to the greater curve in the pyloric third. The stoma runs into and includes the pyloric canal and the ulcer and sear tissue are excised if possible (Fig. 127). In theory the operation is a good one as it allows free drainage and acid neutralisation.

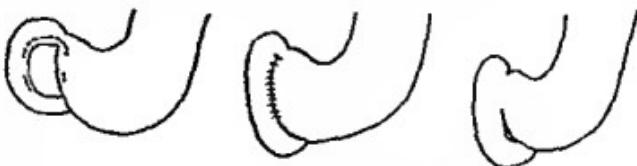


FIG. 127.—Finney's pyloroplasty.

Radiologically the meal is seen to pass freely into the duodenum no pyloric canal or duodenal bulb being present. The junction of pyloric antrum and duodenum is as a rule markedly irregular in contour. The rate of gastric evacuation is not so rapid as in the average gastro jejunostomy.

Marginal ulcer is said to be a rare sequela, but some cases develop adhesions dragging the stoma up to the liver and necessitating subsequent gastro jejunostomy.

BILLROTH II PARTIAL GASTRECTOMY

In the past a popular operation for carcinomas of the stomach or large chronic ulcers in the region of the lesser curve this operation is to some extent being superseded by the Polya types of gastrectomy. It consists of segmental resection of the stomach including the pyloric canal closure of both ends, and posterior gastro jejunostomy (Fig. 128).

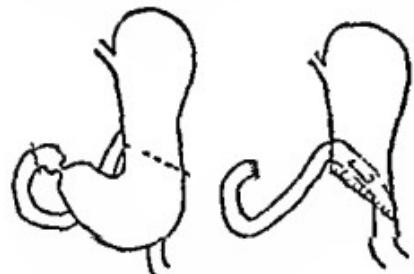


FIG. 128.—Billroth II partial ga. trectomy.

assumes a rounded slightly puckered contour. The stump can best be seen if the efferent jejunal loop be obstructed by a truss. Only then can the stump be properly filled and its contours studied.

Normally there is no reflux from the stomach into the afferent loop and duodenum. But efficient obstruction of the efferent loop by a truss will cause such reflux an appearance which must not be mistaken for a vicious circle. It disappears on removal of the truss.

Radiologically the stomach behaves similarly to the jejunostomised stomach save that the pyloric antrum is absent. At first the gastric stump is small but later it enlarges somewhat. This dilatation is not marked unless contracture of the stoma takes place.

The right blind extremity of the stomach

Complications of the Billroth II Gastrectomy

RECURRENT GASTRIC, STOMAL, OR JEJUNAL ULCER is less common than in gastrojejunostomy, as a considerable proportion of the enzyme-producing mucosa is removed by the operation. The more complete the gastrectomy, the less chance of recurrent peptic ulcer. As, however, this operation does not allow of a very wide resection, recurrent ulceration does occasionally recur, and its radiographic demonstration and appearances are similar to those in gastrojejunostomy.

IN CASES OF CANCER VENTRICULI, local recurrence of the growth is not uncommonly met with. Depending on the precise site of the recurrence, there may result:

(1) *Obstruction of the II hole Stoma*—This causes dilatation of the fundus and oesophagus, and, clinically, vomiting and rapid starvation. The nature of the condition is clearly visible on fluoroscopy and the details of the gastric filling defect in serial radiograms. Discounting the distortion due to the suture line, a recurrence causing the above interference with the stoma usually presents a constant filling defect which is fairly characteristic.

(2) *Obstruction of the Efferent Loop Alone*—The stomach will present similar appearances but in addition the duodenum will be in a state of ileus, and be outlined by the barium cream passing from the efferent limb into it.

(3) *Obstruction of the Afferent Loop Alone*—Again a duodenal ileus results, but as no barium can pass into it, it will be demonstrable radiographically only if it contains gas.

THE POLYA PARTIAL GASTRECTOMY

Polya-Moynihan Partial Gastrectomy (Syn. Anterior left right Polya)—This modification of the original Polya operation is probably more frequently adopted in this country than any other form of partial gastrectomy. It consists of a segmental resection of the lesion bearing portion of the stomach, including the pylorus, as in the Billroth II, with end-to-side anastomosis of the gastric stump to a loop of jejunum. In the original Polya the jejunum was brought up through a

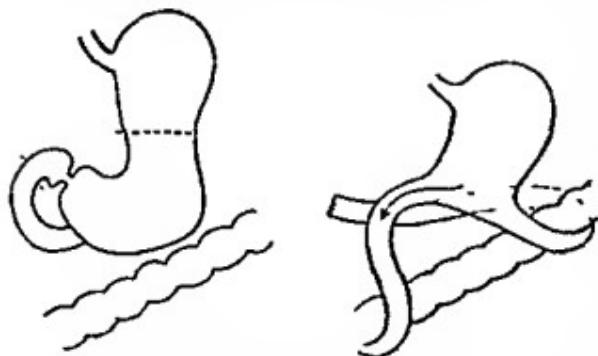


FIG. 129.—Anterior L → R Polya-Moynihan partial gastrectomy

fenestra in the transverse mesocolon. This is said to have the disadvantage in cases of carcinoma that a recurrence, apt to take place near the fenestra,

may cause obstruction of the jejunum. It is avoided by the Moynihan modification, in which a loop of jejunum is carried up in front of the transverse colon. Fig. 129 indicates the direction of the jejunal current (from left to right). The loop is chosen as near to the duodeno-jejunal flexure as possible allowing enough length in the afferent limb to prevent any possibility of tension on it when the patient assumes the erect position.

Polya-Balfour—In Balfour's modification the long jejunal loop is used and the jejunal current is in the reverse direction to that in the Polya-Moynihan. In order to prevent stricture in the proximal limb a lateral anastomosis is made between the two limbs of the loop (Fig. 131).

Modified Polya, with Entero-anastomosis in Y—In this modification a segmental resection is made as before. A jejunal loop is brought up as in the Polya-Balfour, but is divided across. The cut end of the distal limb is closed and that limb anastomosed side to end with the gastric stump. The proximal jejunal limb is then anastomosed end to side with the distal limb an inch or two below the gastric anastomosis (Fig. 130).

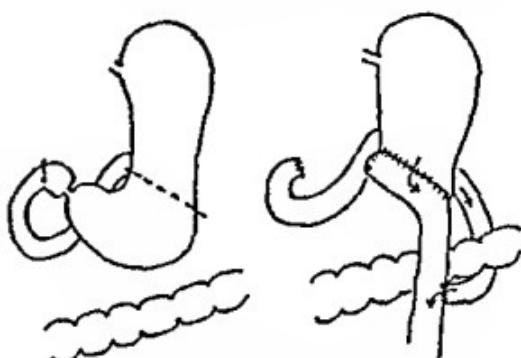


FIG. 129.—Modified Polya partial gastrectomy.
With anastomosis in Y.

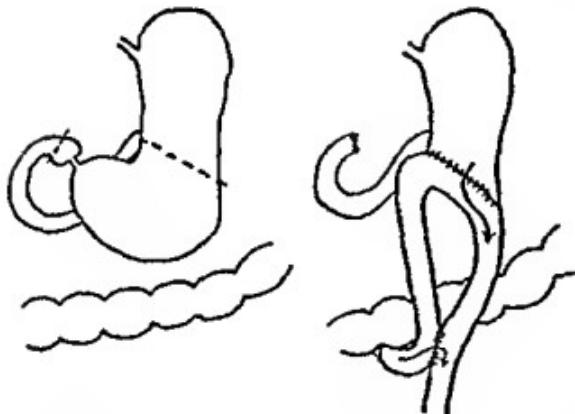


FIG. 131.—Anterior B → I. Polya-Balfour partial gastrectomy with long jejunal loop and entero-anastomosis.

and the anastomosis is seen to be terminal. To study the full contours of the stump control of the efferent loop will be necessary, but this should be preceded by observation of the normal emptying (i.e. without control).

X-ray Appearances in the Polya-Moynihan Partial Gastrectomy

The gastric stump is as a rule smaller than in the Billroth II operation,

Under the screen careful note should be made of the efflux into the jejunum. The barium should be seen to pass chiefly into the efferent limb at the right of the stump. Some will pass into the left or afferent limb but this should not be excessive.

With control of the efferent limb the fundus of the stomach should fill out to a normal contour and there may be some esophageal reflux. The afferent jejunal limb will fill more definitely and active peristalsis will be seen as this loop endeavours to empty itself. The contours in the region of the anastomosis vary considerably depending on the precise position of the suture. A certain amount of puckering is to be expected.

The stomach after this operation empties very rapidly by the time the patient has finished drinking a 12 oz. meal most of it will be in the jejunum and mild jejunal overloading is a common effect of rapid ingestion. Occasionally it may be marked causing a sensation of fullness and dragging in the abdomen. It is therefore important that a patient should masticate thoroughly and eat and drink slowly after having been subjected to this type of operation.

Rardin, Pendergrass, Johnston and Hodes in a paper stressing the effect of different foodstuffs on the rate of gastric evacuation state that this obtained also in the stomach after a Polya gastrectomy and that marked delay can occur after ingestion of fats even if the stoma is large. Such slowing of the rate of evacuation as occurs is the result of diminished gastric tone and peristalsis but in the writer's experience the effect of gravity and the fact that the bottom has literally been cut out of the stomach result in rapid evacuation even when the contrast meal does contain carbohydrates and fats.

Abnormal After-results

RECURRENT PEPTIC ULCER—This an uncommon sequela may be gastric, stomal or jejunal in site. The more complete the gastrectomy the rarer is such a complication. Reentrant gastric ulcer may be on the lesser curve when it will show as a niche or on the posterior wall. In the latter case a relief picture is the best means of demonstrating it.

Stomal ulcer is more easily demonstrable after the Polya type of operation as the stoma is terminal relative to the stomach. As with other forms of stoma residues entangled in puckered mucosa must be differentiated from a barium filled ulcer crater. The latter are more constant in a series of pictures and if the ulcer be deep denser from sedimentation therein. Tenderness on localised pressure over the suspected shadow is an important confirmatory sign.

Jejunal ulcer is more readily visible than in cases of gastroenterostomy as the gastric shadow is not superimposed on the juxta-stomal portion.

OVERLOADING OF THE PROXIMAL LIMB—This rarely occurs in the Polya Movianian operation if the afferent jejunal limb be short and the axis of the stoma properly planned but with a vertically disposed stoma and an unduly long limb some stasis and ileus may be seen. It does however occur in

RECURRENT CARCINOMA if the efferent limb be obstructed by the recurrence. Clinically such cases present characteristic features— inability to eat or drink any but small amounts persistent vomiting epigastric pain and wasting. Radiographically a gastric filling defect near the efferent stoma may be present. Oesophageal reflux and dilatation may occur and the meal is seen to distend the afferent limb (Fig 132). The rate of gastric evacuation is slow unless by vomiting.

Recurrent carcinoma of the gastric stump itself is apt to cause stenosis at or just above the stoma. Clinically the symptoms are as above described and radiographically a considerable filling defect of the stump wall will be apparent.

Scarring from recurrent simple ulceration may also cause obstruction of the stoma or either jejunal limb efferent or afferent with similar appearances to those in the carcinomatous variety save that there will not be present a gross filling defect of the stump itself.

X-ray Appearances in the Polya-Balfour and Polya In Y Operations

The appearances will vary from those above described chiefly in the site of the efferent jejunal limb which is situated at the left angle of the stump. In the Balfour modification some barium may pass into the afferent loop but this can cause no trouble because of the jejunoojejunostomy below. In the in Y type again no overloading of the afferent limb can occur. With these exceptions the abnormal after-effects are similar to those described in the case of the Polya-Moylan

POLYAN WITH RESTRICTED STOMA POLYA-LAKE POLYA-FINSTERER

The Polya-Lake modification judging by the radiographic appearance controls the efflux of the gastric contents better than any other of the Polya type. In addition to preventing dumping into the jejunum it renders reflux into the efferent loop very improbable.

In it a short jejunal loop is brought up through the transverse mesocolon the jejunal current flowing from right to left. Although the jejunal loop is



FIG. 13.—A R → L anterior I o l a partial gastrectomy for carcinoma w t h recurrence obstructing the efferent jejunal limb and loss of the afferent

sutured along the whole length of the cut gastric stump only a small stoma about 1½ inches in length is made at the lower end (Fig. 133)

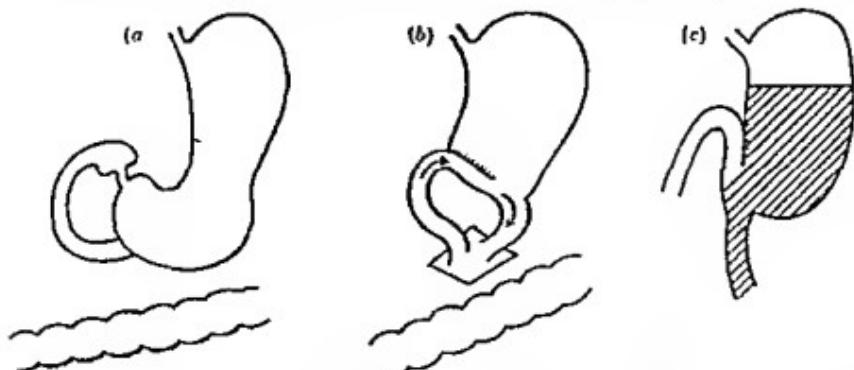


FIG. 133.—The Polya-Lake partial gastrectomy. (a) The resection. (b) The anastomosis. (c) The radiographic appearance.

Finsterer's modification is in essence the same.

RADIOGRAPHICAL FEATURES.—The gastric stump fills reasonably well in the



FIG. 134.—Normal radiographic appearance after the Polya-Lake partial gastrectomy.

erect position and the stoma is clearly seen at the lower pole. The right border of the stump is formed by the remaining portion of the lesser curve and

the sutured end of the stump above the stoma. This largely loses its initial angularity and becomes more or less straightened out. At the junction of the two there is apt to remain a dimple which must not be mistaken for a recurrent lesser curve ulcer. The greater curve of the stump balloons out to form quite a respectable lower pole (Fig. 134).

Recurrent inflammatory and ulcerative sequelæ are very rare after this operation. Late found three cases of jejunal ulcer in 300 patients subjected to the operation.

The valuable feature of this operation is the restriction of the size of the stoma which leads to gradual expansion of the gastric stump and the formation of a satisfactory gastric reservoir.

The position which the suture line assumes after the operation (it forms virtually a new lesser curve) is of importance in the technique. The anastomosis must be of the right → left variety. The effect of the stoma restriction

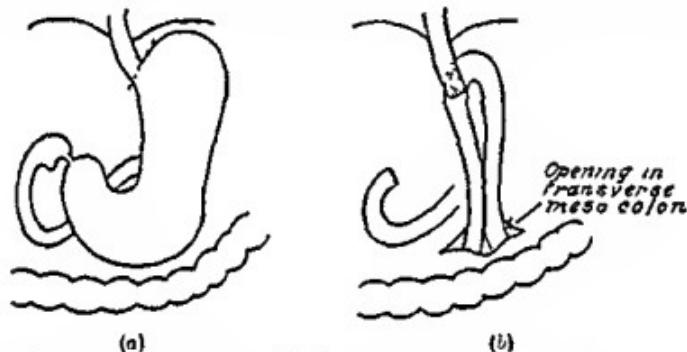


FIG. 13.—Complete Gastrectomy. (a) The resection. (b) The completed operation.

in preventing reflux into the afferent limb has precisely the reverse effect if the stoma is restricted in a left → right anterior Polya Moynihan. In this case the gastric contents are inevitably shot into the afferent limb and a vicious circle results.

COMPLETE GASTRECTOMY (MOYNIHAN)

This a difficult operation technically, and attended by an appreciable immediate mortality, is indicated in some cases of gross scirrhouous carcinoma of the leather bottle type. It consists of resection of the whole stomach and end in side or side to side anastomosis of the lower end of the oesophagus with a long loop of jejunum. The latter is brought up through a fenestra in the transverse mesocolon. The two limbs of the jejunum may be anastomosed lower down to short circuit the bile and pancreatic secretions (Fig. 135).

Early X-ray Appearances after Complete Gastrectomy

Of two cases examined by the writer one was performed according to the above technique. In it, one month after the operation the anasto-

had already begun to dilate and to form a pseudo fundus (Fig. 136). In the other case the cut end of the oesophagus was anastomosed to the pyloric antrum close to the pyloric canal. A month after the resection the lower oesophagus had begun to dilate and take over the duties of reservoir. An interesting point in the second case was that the pylorus remained widely open, doubtless from the destruction of its sphincteric reflex nervous control.



FIG. 136.—Appearance of the anastomosis one month after complete gastrectomy.

Late X-ray Appearances after Complete Gastrectomy

Butler has described the appearances in a case six months after complete gastrectomy. The feature in it was a considerable dilatation of the jejunum close to the oesophageal stoma. The dilated portion was ballooned into the left dome of the diaphragm contained a gas bubble, and simulated the fundus of a normal stomach. Doubtless the constant upward pressure of gas in this loop contributed to this effect. Barium remained in this diluted pseudo fundus for more than five minutes. At the end of an hour all the barium had accumulated in the pelvic coils of the ileum. Transit is therefore rapid, as in the partial gastrectomy cases.

CHAPTER XIV

THE DIAPHRAGM

In this section the diaphragm in relation to the abdomen will be considered.

Anatomy—The diaphragm a dome shaped musculo aponeurotic partition between the thoracic and abdominal cavities is composed of a central trefoil shaped tendon, and surrounding it a peripheral sheet of radiating muscular fibres. The muscular fibres are all inserted into the central tendon, and take their origin from the following points:

- (1) Anteriorly by two fleshy slips from the body of the ensiform cartilage.
- (2) On either side from the ribs and costal cartilages, interdigitating with the *transversalis abdominis*.
- (3) Postero laterally from aponeurotic arches the *ligamenta arcuata*.
- (4) Posteriorly from the lumbar vertebra by two crura. These crura arch over the aorta to form the aortic opening decussate and separate to form the oesophageal opening, and then fuse with the central tendon.

On each side there are two gaps in the diaphragmatic attachment of importance in diaphragmatic herniae—the foramen of Morgagni between the sternal and costal attachments and the costo lumbar angle the site of the embryonic pleuro peritoneal hiatus.

The diaphragm presents three main openings. Two have already been mentioned both again of importance as hernial sites. The third the foramen for the inferior vena cava, pierces the central tendon in front and to the right of the oesophageal opening.

INTRA-abDOMINAL RELATIONS—The right dome of the diaphragm is accurately moulded over the convex surface of the right lobe of the liver, the right kidney and the right suprarenal capsule, the left dome over the left lobe of the liver, the gastric fundus the spleen the left kidney and left suprarenal capsule.

NORMAL RADIOLOGICAL APPEARANCE OF THE DIAPHRAGM

The domes of the diaphragm appear in a postero anterior radiogram or on fluoroscopy as smooth rounded contours stretching from the cardiac shadow to the ribs laterally. The junction with the cardiac shadow is at about a right angle. Sometimes the angle is a little more obtuse sometimes more acute.

The costophrenic angles laterally are clear cut and very acute in expiration. They open up but remain pointed on forced inspiration.

Frequently the domes show a slightly wavy contour, due to the muscular bands of the diaphragm producing shallow ridges.

The right dome is usually about a centimetre higher than the left due to the larger mass of the right lobe of the liver

Movements of the Diaphragm —The respiratory excursion of the diaphragm during quiet breathing is 1-2 cm. In forced respiration it may be 2-6 cm or more. It is greater in abdominal breathing than in thoracic. Viewed in the postero anterior plane the descent of the diaphragm is seen to consist of a lowering of the central tendon to some extent while the two domes as they descend become flattened and thus show a greater range of movement than does the central tendon. The latter is to some extent anchored by the heart and pericardium.

In the lateral view the posterior attachment of the diaphragm is seen to be about 3 inches below the anterior. The anterior portion beneath the heart is roughly horizontal and the diaphragm slopes down increasingly as it is traced backwards. The posterior part shows a greater respiratory travel than the anterior.

IRREGULARITIES IN THE DIAPHRAGMATIC CONTOUR

The commonest is upward displacement of one or both domes. Upward displacement of the whole diaphragm occurs from any increase in the intra-abdominal tension. Typhoid fever from any acute illness has this result. If ascites it occurs to a marked degree. Pregnancy, large ovarian cysts or indeed any large abdominal tumour will cause it.

Upward Displacement of One Dome —The causes of this are many—intrathoracic diaphragmatic and intra-abdominal. The intrathoracic causes are dealt with in their appropriate sections.

Of the diaphragmatic and abdominal causes the following call for mention:

- (1) Diaphragmatic hernia. This although not a true upward displacement raises the radiographic contour and is conveniently grouped here.
- (2) Phrenic nerve paralysis.
- (3) Eventration.
- (4) Temporary distension of the gastric fundus by air.
- (5) Subphrenic abscess.
- (6) Subhepatic abscess.
- (7) Enlargement of either lobe of the liver from neoplasm, liver abscess, hydatid cyst, etc.
- (8) Gross enlargement of the spleen.
- (9) Large renal tumour which raises the posterior part of the diaphragm.

DIAPHRAGMATIC HERNIA

Embryology

For a proper understanding of the congenital types of diaphragmatic hernia some appreciation of the development of that structure is necessary.

In the early embryo the pleural cavities protrusions of the primitive

cælom, communicate freely with the peritoneal cavity. The diaphragm which eventually separates them is a composite structure embryologically (Fig. 137).

The ventral half is formed from the septum transversum, a mesodermic partition separating the heart from the abdominal viscera. It first lies obliquely in the neck, but gradually moves down and assumes a transverse disposition. It reaches its final position opposite the level of the 12th rib at about the fourth week. In its descent it carries with it its nerve supply from C 3, 4, and 5—the phrenic nerve. The point of entry of the latter into the adult diaphragm marks the posterior limit of the portion formed from this septum.

The posterior half of the diaphragm is formed from three structures—the primitive mesentery of the foregut stretching between the dorsal cælomic wall behind and the septum transversum in front, and the pleuro peritoneal folds, one growing inwards from each lateral cælomic wall to fuse with the septum transversum and the medial mesentery. The last portion to fuse is the postero-lateral, where for a time there persists on each side, the pleuro peritoneal canal or hiatus. Failure of this hiatus to close accounts for a common type of hernia.

Classification

The following classification is adapted from Hume. By the term congenital is meant any hernia which occurs through a region of the diaphragm where there is a developmental hiatus or weakness i.e. in cases where there is a developmental explanation for the site of the herniation.

CONGENITAL

- (1) Through the pleuro peritoneal hiatus
- (2) Through the dome
- (3) Para œsophageal
 - (a) Through the hiatus
 - (b) Thoracic stomach
- (c) Non development of crura
- (4) Through the foramen of Morgagni

ACQUEREN

- (5) Non traumatic
- (6) Traumatic (i.e. resulting from wounds)

Anatomical Features

(1) HERNIA THROUGH THE PLEURO PERITONEAL HIATUS.—This hiatus is patent for the first three months of foetal life. It is situated between the costal

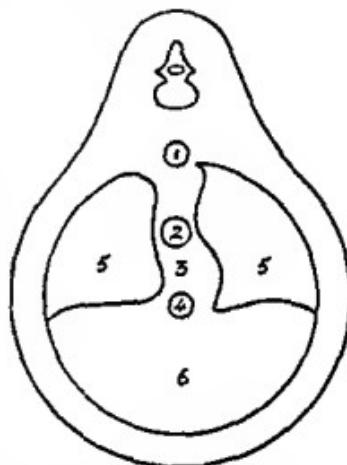


FIG. 137.—Diagram showing the components which form the diaphragm.

1 Aorta 2 Oesophagus 3 Medial mesentery 4 Inferior vena cava 5 Pleuro peritoneal folds 6 Septum transversum

and spinal muscle fibres. At birth a fibrous area marks its site—the lumbo-costal triangle close to the arcuate ligament. All stages of hernal defect may exist from a small gap to almost complete absence of that half of the diaphragm. It is usually incompatible with life as herniation takes place when breathing is established and strangulation or paralytic ileus supervenes in a few hours or



FIG. 134.—Congenital hernia of the stomach through a large right pleuro-pelvic fistula. Female, 3 months, admitted to Hospital with bronchopneumonia and intermittent attacks of vomiting.

At post mortem the stomach was in the right thorax but slipped back into the abdomen. This explained the intermittent vomiting. The oesophagus was not shortened.



FIG. 135.—Herniation of the stomach through the right lobe of the diaphragm.

days. These cases do not as a rule find their way into an X-ray department. A plain radiogram of the chest may indicate the nature of the condition by the presence of gut and other viscera in the pleural cavity (Fig. 138). In the gross cases the condition may be associated with non-rotation of the gut.

(2) HERNIA THROUGH THE DOME.—This occurs usually on the left side, the liver effectively protecting the right dome. The evidence in favour of some of these cases being congenital is that several cases have been recorded in newborn infants. The gap in the dome varies in size but is fairly constant in

position, in the left trefoil of the central tendon, immediately behind the entry of the phrenic nerve into the diaphragm. It is explicable on the assumption that the plenoro peritoneal membrane fails to unite completely with the septum transversum. It is a rare form of hernia. The stomach and a portion

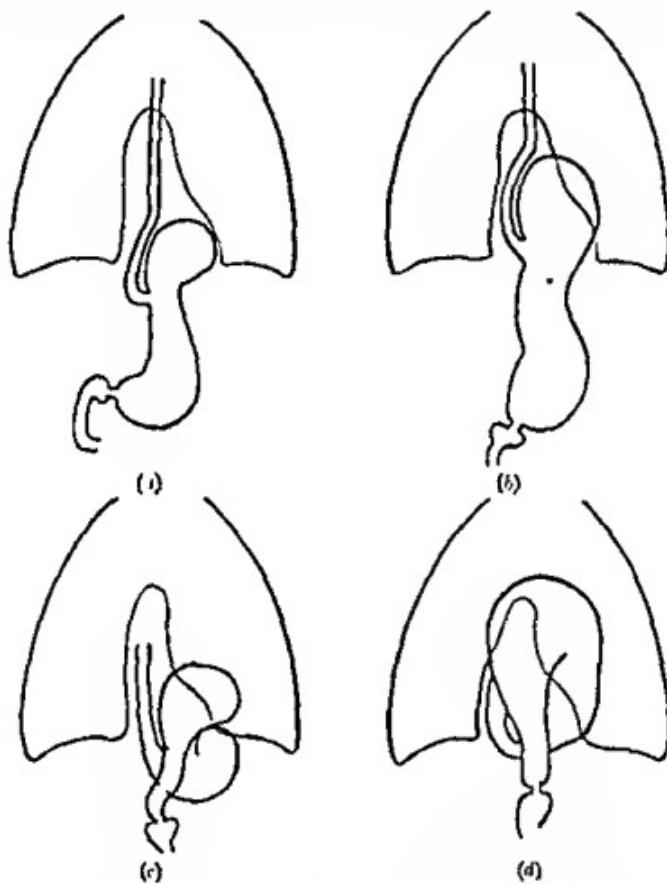


FIG. 140.—Paraoesophageal hernia of the stomach

- | | |
|------------------------------|---|
| (a) Hernia of the fundus | (b) Hernia of the upper half of the stomach |
| (c) Hernia of the pars media | (d) Hernia of the whole stomach |

of the colon are invariably herniated, and, when the gap is large, the spleen and portions of the small intestine also. Fig. 139 represents an unusual type, herniation of the stomach through the right dome.

(3) PARAOESENAGEAL HERNIA.—While herniation through the plenoro-peritoneal hiatus is the commonest type of diaphragmatic hernia found in the fetus, these are usually incompatible with life, and in adults the paraesophageal type is much the commonest.

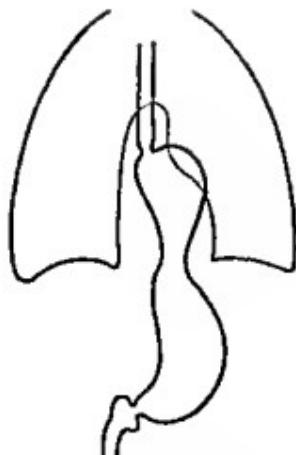


FIG. 140.—Congenital partial thoracic stomach

Two types occur—a true herniation through the oesophageal orifice, which may or may not be associated with incomplete development of the crura (Fig. 140) and a partial thoracic stomach (Fig. 141).

In the former type the gastric fundus is displaced upwards into the posterior mediastinum the oesophagus being of normal length and folded somewhat on itself. In most cases the fundus is to the left of the oesophagus encroaching on the left pleural cavity. In one of the writer's cases the herniation took place to the right side of the gullet.

The partial thoracic stomach results from failure of that viscous to descend from the primitive thoracic coelom with the descent of the septum transversum. The forming diaphragm then traps a varying portion of the stomach above it. The amount varies from almost the whole of the stomach to a

small portion of the fundus. The oesophagus is short to a degree corresponding to the position of the stomach. The latter is somewhat constricted at the oesophageal opening the opening being larger than the normal but smaller than the full lumen of the stomach. The distinguishing feature between this type and the true paraoesophageal hernia is the short oesophagus.

(4) HERNIA THROUgH THE FORAMEN OF MORGAGNI
—These are very rare. The sac lies behind the sternum and may contain colon or small intestine. Postero-anterior and lateral views are necessary to demonstrate them (Fig. 142).

(5) ACQUIRED NON TRAUMATIC HERNIA—These are rare and may occur in any part of the dia phragm except the central part of the tendon. Their appearance depends on the precise site and degree. The commonest site is through the left dome of



FIG. 142.—Hernia of the stomach through the foramen of Morgagni (lateral view).

1 Stomach 2 Oesophagus 3 Diaphragm

the diaphragm. They are regarded as non congenital in that they herniate through a part of the diaphragm which is not the site of a possible developmental fault or weakness.

(6) TRAUMATIC HERNIA, i.e. hernia following on wounds of the diaphragm, were common during and after the Great War. Like the acquired non traumatic variety, they were commoner through the left dome of the diaphragm on account of the protective mass of the liver on the right.

COMPLETE THORACIC STOMACH — Numerous cases of this are now on record.

R E Roberts has described a case in a female of 3 years and 10 months. The oesophagus was short and the stomach bilocular. Fig 143 shows the disposition in his case. Three similar cases had been previously reported by Bailev and Lelland, and a subsequent one by Dunhill. A feature in these cases, as in one of the writer's (Fig 144), is that the viscera is upside down. The greater curve is uppermost and the cardia and pyloric region form the lowest points.

The liver and spleen may be involved in a hernia, these are described in the section on the lungs.

Radiological Features

TECHNIQUE — Many diaphragmatic herniae are visible on plain fluoroscopic inspection of the diaphragm. The erect position is the most satisfactory for this purpose. Above the diaphragmatic line will be seen a projection, the hernial sac, in which, if it contains stomach or colon will be seen one or more air bubbles and possibly fluid levels below the gas. If such a hernial protrusion is visible in a postero anterior view, rotation of the patient will show whether the herniation is at the lumbo costal angle through the dome, or anterior. The

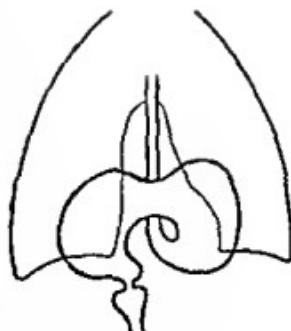


FIG. 144.—Complete thoracic stomach.
The organ is upside down, the greater curve being uppermost.

paraoesophageal herniae may easily be overlooked in a postero anterior view as they are then apt to be masked by the cardiac shadow. If their presence is not suspected clinically, the only clue to their existence in such a view may be a faint gas bubble shadow with or without a fluid level.

An opaque meal examination should be used in all cases of diaphragmatic hernia as a great deal of information is obtainable by such a method. The examination should be continued until the splenic flexure is visualised in case that structure is herniated. It may be necessary to employ a barium enema for this purpose.

Radiographically the diaphragmatic herniae fall into two groups—those which herniate into the pleural cavity and encroach chiefly on the lung space and those—the paraoesophageal group—which encroach largely on the posterior mediastinal space. The demonstration of the first is fairly simple with a barium meal examination; in the elucidation of the latter it may tax one's ingenuity considerably to obtain separate shadows of the stomach, oesophagus and other herniated structures.

IN HERNIA OF THE STOMACH THROUGH THE DORSO AND LUMBO COSTAL ANGLE the oesophagus is seen to be displaced at its lower end towards the hernia. The stomach if herniated should be examined with the patient erect, prone and supine. In the erect posture the lower pole of the stomach shows a characteristic appearance. As the fundus is raised the drag on the lower half of the stomach undoes the pyloric curve or hook to some extent so that the incisura tends to disappear, the pyloric canal to point to the right and slightly downwards and the duodenal bulb to lie on a lower level than the pars pylorica. This appearance is seen in any considerable herniation of the stomach of this type or the paraoesophageal.

In the prone or supine position—usually the latter—the upper half of the stomach fills and the precise position of the fundus filled with barium is easily determined. The usual biloceleation of the stomach caused by the hernial orifice is also visible. In the region of the hernial orifice the gastric rugae can be followed from upper to lower loculus. A later stage in the examination will show whether any of the small intestine or colon is in the sac. The presence of the spleen in the hernia is indicated if there is a considerable uniform opacity to be seen in the sac. Rotation of the patient during screening and radiograms taken in two planes serve to determine the precise site of the herniation.

In some cases if the hernia is small and not incarcerated it may be visible only with the patient lying down or in the Trendelenburg position.

The chief problem in the differential diagnosis of this group is in distinguishing it from evagination of the diaphragm (*q.v.*)

THE PARAESOPHAGEAL GROUP may not be seen on plain radioscopic inspection of the thorax but as they tend to give oesophageal and/or gastric symptoms they are commonly examined with a barium meal. As the

opaque cream is traced down the oesophagus the gastric fundus can usually be made out above the diaphragm and close to the oesophageal shadow.

Having established the presence of a lesion belonging to this group, it becomes of first importance to determine whether it is a true herniation or a partial thoracic stomach. The former is amenable to surgical treatment the latter is not. They can best be differentiated by the use of the 'double swallow' method in the Trendelenburg position as follows:

The patient is first given enough of the opaque cream to fill the stomach reasonably full and then is placed in the Trendelenburg position on the X-ray table. By this procedure the herniated fundus filled with the contrast medium, is visible. The patient is then given a large mouthful of the cream from a feeding cup and the progress of the barium watched under the screen from the moment it is swallowed until it reaches the cardia. Still in the Trendelenburg position the patient should be rotated right and left until a clear view of oesophagus, cardia and gastric fundus is obtained. When this view is obtained it can then be seen whether the oesophagus is of normal length or congenitally short. One of normal length takes a looped course as it approaches the cardia indicating that a true herniation has occurred (Fig. 145). If on the other hand the oesophagus runs straight down to the cardia the case is one of thoracic stomach (Fig. 146). To obtain a film showing this appearance with oesophagus, cardia and fundus filled the time taken by an opaque bolus to pass down to the cardia should be measured fluoroscopically. Usually it takes two to three seconds. An exposure is then made the appropriate number of seconds after the patient swallows the bolus.

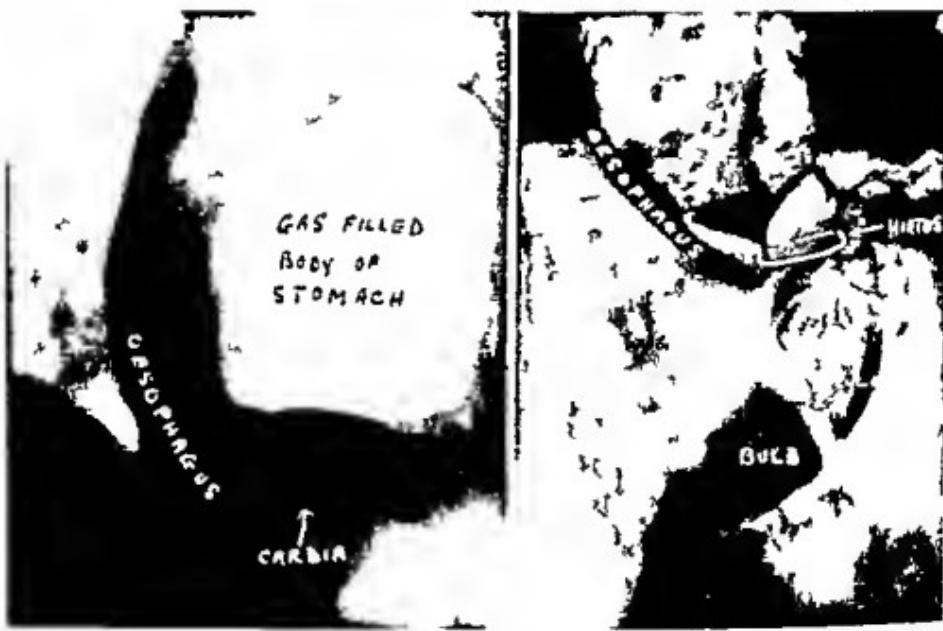


FIG. 145.—*A rare oesophageal form of the stomach showing the angulation of the oesophagus.*

In gross herniation of the stomach in which most of the viscera or all of it is in the thorax there is a tendency also to inversion (Fig. 147). The greater curve swings upwards and forms the highest portion of the herniation. The pylorus and cardia may be located fairly close together at the hernial



FIG. 140.—Partial
thoracic stomach with
soft mesopharynx.
1 Oesophagus 2 Car-
dia 3 Cæstrum fundus
4 Diaphragm



14.—Large oesophageal lumen of the stomach of the type shown diagrammatically in Fig. 140 (f).



FIG. 149.—Congenital partial thoracic stomach with short oesophagus



FIG. 149.—Para-oesophageal hernia of the stomach, the fundus passing into the right side of the thorax. This view (right anterior oblique) shows the abrupt angulation of the oesophagus where it reaches the gastric fundus.

hiatus if the latter is small. It is surgically of great importance in these cases to demonstrate the size of the hiatus, since those with a very wide opening may be difficult to repair. The hiatus is rendered visible when the two "limbs" of the herniated viscera, afferent and efferent, are filled, and the technique of examination should be directed *inter alia* to this point.

Dunhill points out that in many cases of partial congenital thoracic stomach with short oesophagus the cardia is at the top of an ill developed fundus (Fig. 148).

When examined erect, the narrowing of the barium shadow may simulate a carcinoma of the stomach. In the Trendelenburg position the fundus becomes distended with barium, and the gastric rugae at the diaphragmatic hiatus can be made out. These two points, in addition to the short straight oesophagus, indicate the true nature of the condition. This authority also draws attention to a common and characteristic appearance in the oesophagus in true para-oesophageal herniation. The oesophagus runs straight down to a point just short of the herniated fundus, and then makes an abrupt angulation, usually backwards and to the right, to sweep round the fundus in a loop (Fig. 149).

ACQUINER AND TRAUMATIC HERNIA—Acquired non-traumatic herniae are commonest in the left

dome and traumatic hernia occur at the side of the wound of the diaphragm. Radiographically they fall into one of the groups above described—usually the former. They should be radiologically examined in the manner already described.

EVENTRATION OF THE DIAPHRAGM

(*Syn.* Petit's eventration. *Relaxatio* or *eventratio diaphragmatica*, Unilateral congenital elevation of the diaphragm)

In this condition the affected dome is in the form of a thin fibrous sheet, ballooned up into the thorax. In the vast majority of cases it occurs on the



FIG. 160.—(a) Petit's eventration with marked displacement of heart as it tended to turn to the right. The stomach was rotated with the greater curve uppermost.

(b) The same case supine. The gastric rotation has reduced itself.

left side. At the time of writing only nineteen cases of right-sided eventration have been recorded.

The abnormality was first described by *Petit* (1674-1750) a French surgeon. He recorded two cases, one of which appears to have been a true eventration and the other a diaphragmatic hernia. *Woodburn Morrison* gave a full account of the condition in 1922.

Etiology—This is still obscure. Paralysis of the phrenic nerve when developed gives an appearance exactly similar to the idiopathic or congenital eventration and it is tempting to ascribe all cases of eventration to that cause. This could not account for the large preponderance of cases of eventration which

occur on the left side as phrenic nerve paralysis occurs on either side impartially. Again in certain cases of congenital eventration which have gone to autopsy the phrenic nerve showed no abnormality.

On the evidence available so far it appears probable that there are two types

(1) Congenital occurring on the left side almost exclusively

(2) Secondary to phrenic nerve paralysis and occurring equally on either side

The only features that help in distinguishing between them are the side on which the lesion occurs and any history of damage to the phrenic nerve.

PATHOLOGY —The affected dome is composed of a thin fibrous sheet displaced two to three interspaces upwards in the thorax. Very commonly it is situated on a level with the fourth interspace anteriorly. As a rule there is no trace of muscular tissue in the fibrous dome.

Radiological Features

Woodburn Mori on grouped the radiological features under the following headings

(1) **THE DIAPHRAGMATIC OUTLINE** —This is high—several interspaces higher than the normal—and forms a regular bow line or arc right across the hemithorax. This arc is maintained by the ballooned gastric fundus. If the splenic flexure is gas distended also and in the dome there may be a slight notch in this arc at the point of apposition of the two structures. Diaphragmatic hernia usually presents a different appearance. The hernial sac produces a hump in the diaphragmatic outline and some portion of the diaphragm is usually visible. If the hernia is very large resulting from almost complete absence of the left dome it may be impossible to distinguish it from an eventration. Such hernial defects are as a rule incompatible with life.

In right sided eventration the dome is not so high and shows no gas below it. In place of the dilated fundus tending to lift the dome there is the main mass of the liver restraining the upward thrust of the abdominal musculature.

(2) **THE CONTENTS OF THE DOME** —On the left the greatly distended gastric fundus occupies the greater part of the dome. The splenic flexure also has its place therein and at a lower level the spleen. On the right side the dome is occupied by the liver.

(3) **LIQUID TISSUE VISIBLE THROUGH THE DOME** —This will be seen if the gaseous distension is considerable and the lung tissue at the base of the lung posteriorly normally expanded.

(4) **MOVEMENTS OF THE DOME** —These are of prime diagnostic importance and should be noted most carefully. Movements are either absent or more commonly paradoxical i.e. an upward excursion takes place during inspiration and vice versa. These paradoxical movements are never marked. They are known on the Continent as Kienbock's sign and are said to occur occasionally in large herniae.

(5) THE GASTRIC CONTENTS.—A fluid level is commonly visible, unless the stomach is empty. This level is stated always to be at that of the cardia. This is explicable on consideration of the mechanism of eructation of gas. This takes place usually when the individual is in the erect position. Gas will be expelled from the stomach during eructation up to the point where the fluid gastric contents rise and seal off the cardia. At that point escape of gas from the distended fundus into the gullet is stopped and consequently the fluid level is prevented from rising above the cardia.

If the fluid level is of fair extent palpation of the abdomen causes ripples in it. These are clearly seen on screen examination.

(6) CARDIAC DISPLACEMENT.—The heart usually shows some slight displacement to the right and also slight abnormal respiratory excursion moving to the right on inspiration.

(7) GASTRIC DEFORMITY.—This is present fairly constantly, and is of the nature of a biloculation. According to *Morison* it is caused by an upward displacement of the greater curve into the dome, and a rotation of the stomach on its fixed points cardia and pylorus. This torsion may amount almost to a volvulus and produces the bilocular appearance.

Of the above signs the contour of the dome its position and its movements are constant and cardinal, the others are not always present.

Differential Diagnosis.—Temporary elevation may occur from marked gaseous distension of the stomach. The elevation is not usually so marked and the diaphragmatic movements are normal. In hernia through the dome the contour of the dome is less regular. In one view at least, the postero-anterior oblique or lateral the normal portion of the dome will be visible (with the exception of the rare cases of complete absence). The movements of the sac are variable. There may be none or they may be reversed, or they may follow the movements of the remainder of the diaphragm. The clue lies in the latter. If any of it is visible fluoroscopically, its respiratory movements are seen to be normal.

J. Quenu has suggested two measures which might be of use in the differential diagnosis between evantraion and a large hernia through the left dome. (1) Pneumo peritoneum may enable the diaphragmatic and gastric fundal shadows to be seen dissociated. This is hardly practical politics. (2) Faradic stimulation of the phrenic nerve may produce visible movement of the remains of the diaphragm in a large hernia when none can be made out on ordinary forced respiration.

PARALYSIS OF THE PHRENIC NERVE

This may result from many causes such as wounds in the neck, or pressure in the neck or the thorax—especially from mediastinal tumours. It is commonly induced therapeutically in cases of bronchiectasis and pulmonary tuberculosis, and the sequence of events following phrenic avulsion is now

well known. For a few days after section of the nerve slight normal movements take place in the paralysed dome. Then over a period of two weeks the affected dome gradually ascends in the thorax and either becomes immobile on respiration or presents reversed movements usually slight in range. During this period atrophy of the muscle takes place. On the left side thinning and stretching of the degenerated muscle continue until in some cases the typical picture of left sided eventration is reached.

SUBPHRENIC ABSCESS

Subphrenic abscess arising as a complication of perforated peptic ulcer, gall bladder disease or appendicitis may occur on either side. On the right side the abscess forms between the liver below and the diaphragm above. On the left side the lower boundary is formed by stomach and spleen.

X-ray Features—In a typical case the dome is rather high—a centimetre or two raised—and may be fixed on respiration. The diaphragm is rendered immobile by a protective reflex similar to that which places the abdominal musculature on guard in peritonitis. Any deformity of the contour is unusual. In a percentage of cases gas is present in the abscess cavity (Fig. 151). This arises either from the passage of air from the stomach through a perforation or from the direct action of gas forming organisms such as *B. welchii*.



FIG. 151.—Subphrenic abscess with formation of gas under the right dome.

On the right side of the abdomen this gas is obvious if the patient be examined erect and although these patients are as a rule very ill a radiogram can usually be obtained with the patient sitting up in bed. In such a posture the gas is clearly seen in a layer between diaphragm and liver. If the amount of gas present be considerable a fluid level in the abscess cavity will be apparent. Two other conditions can give a somewhat similar appearance of gas in this region. On rare occasions a loop of transverse colon wanders up between the liver and diaphragm and may contain gas. Again in a para-cesophagael

hernia the herniated gastric fundus may lie to the right of the oesophagus. The clinical features are enough to exclude these two.

On the left side the dome is raised and immobile but if gas be present it may be difficult or impossible to differentiate it from gas in the stomach or colon.

Changes in the base of the lung overlying the abscess are commonly found. A small pleural effusion enough to fill up the costo-phrenic angle is frequent. In the lung itself a varying degree of *stippled opacity* disposed in horizontal layer across the base and a little above the diaphragm is a usual appearance in these cases. This represents a congestive reaction with some degree of collapse from the upward displaced diaphragm. If the opacity in the base of the lung be considerable it may be difficult to decide whether a pneumonic consolidation and not a subphrenic abscess is the cause of the trouble.

SUBHEPATIC ABSCESS PERIRENAL ABSCESS

In this condition the dome is raised a little and fixed no pulmonary changes are present as a rule. It is described in the section on the urinary system.

TUMOURS AND ENLARGEMENTS OF THE LIVER

The exact amount of elevation of the dome and the degree of distortion thereof will depend on the nature of the hepatic enlargement. Hydatid cysts and tumours if situated near the upper surface of the liver may produce mild rounded bulge in the diaphragmatic contour but usually no such deformity is produced.

Hepatic enlargements from general diseases such as cirrhosis or congestion produce no distortion of the outline. In examining these hepatic abnormalities radiographically it is important to take note of the position of the lower edge which is usually visible in a plain radiogram of the upper abdomen.

GROSS ENLARGEMENT OF THE SPLEEN

This may raise the left dome to some extent. The clinical evidence is decisive.

FREE GAS IN THE PERITONEAL CAVITY

As this is usually demonstrated radiographically in relation to the diaphragm it may be considered here. It may result from:

A **LAPAROTOMY**—This is the commonest cause and on being present with a radiogram showing gas in the peritoneal cavity this point should first be determined. Air is slowly absorbed and traces may be found in the abdomen a week after operation.

B **PERRORATIONS OF THE ALIMENTARY CANAL**

C **GAS FORMING ABSCESES e.g. subphrenic**

D ACCIDENTAL PUNCTURES of the abdominal cavity during artificial pneumothorax, etc

E AIR INSUFFLATION OF THE FALLOPIAN TUBES, if successful

Radiological Demonstration.—The best site to demonstrate free air is under the right dome of the diaphragm. This normally contains no gut; the liver keeps the latter well removed. The examination, screening and radiographic, should be in the erect or sitting posture, usually the latter is all that is possible, but it suffices. If only the recumbent posture is permissible, the patient should be placed on his left side, the tube centred horizontally in front of him, and the film behind. The radiogram will show air between the lateral abdominal wall and the liver. If, in the sitting position, a crescent of gas is seen between the liver and diaphragm, it is almost certainly due to free air. One fallacy already mentioned must be taken into account, that of hepato dia phragmatic interposition of the colon. On the left side the gas bubbles in the stomach and splenic flexure complicate the appearance, but if much free gas be present, it can be recognised also on this side.

REFERENCES

- ADAMS, A. W., *Brit Med J*, 1925, I, 248
 ÅKERBLÖM, Å., *Acta Radiol*, 1923, II, 14
 ALBRECHT, H. U., *Fortschr geb Röntgenstr*, 1929, XXXIX, 231
 BARCLAY, A. F., 'The Digestive Tract,' London, 1926
 BEHING, L., *Acta Path Microbiol Scand*, 1933, Supp XVI 18-30
 BFRG, A., 'Röntgenuntersuchungen am Innenschleif des Verdauungskanals,' 1930,
Brit J Radiol, 1925, XXX, 372. *Ibid*, 1933, XIII, 87
 CAPMAN, R. D., 'Roentgendifagnosis of diseases of the alimentary canal,' Philadelphia, 1920
 BUTLER, H. B., *Brit J Surg*, 1927, XI, 316
 CASE, J. T., *J Amer Med Ass*, 1929, LXXV, 1463
 CHAOLI, H., 'Klinische Röntgendiagnose des Verdauungskanals,' Berlin, 1928
 DIVAL, P., and BRICLERE, H., *Pr Med*, 1932 XL, 981
 DINSMORE, T. P., *Brit J Surg*, 1935, XXII, 475
 DUSTEFAN, Geo B., *J Amer Med Ass*, 1931, XCVI, 173
 FORESTELL, G., *Amer J Roentgenol*, 1923, X, 87. *Acta Radiol*, 1924, III, 217-18
 FRANKEI, A., *Fortschr geb Röntgenstr*, 1927, XXXVI, 687. *Brit J Radiol*, 1927,
 XXXII, 405
 GAGE, H. COLLETTESY, *Proc R Soc Med*, 1937, XXX, 1371
 HUME, J. B., *Brit J Surg*, 1932, XIX, 527
 HURST, A. F., *Quart J Med*, 1915, VIII, 300
 HURST, A. F., and BRIGGS, P. J., *Guy's Hosp Rep*, 1924, LXIV, 432
 HURST, A. F., and STEWART, M. J., 'Gastric and Duodenal Ulcer,' London, 1929
 KADENKA, S., *Acta Radiol*, 1935 XVI, 311
 KELLOGG, F. L., 'The Duodenum,' New York, 1933
 KEPPEL, P., 'Recent Advances in Radiology,' London, 1936
 KIRKLIN, B. R., *Amer J Roentgenol*, 1933, XXIX, 4. *Ibid*, 1934, XXXI, 581
 KRAUS, I., and BECK, W. C., *Ann Surg*, 1931, XCIV, 311
 LAKE, N. C., *Brit Med J*, 1927, II, 49
 LEFOLY, L. FRANCOIS, R., and GARCIA CALDERON, J., *Arch Mal apparem digestif*, 1933,
 XXIII, 533
 LEWALD, L. J., *J Amer Med Ass*, 1931, XCVI, 179
 LINCOLN, H., *Arch Path Gen*, 1914, XVII, 445

- MACCARTY, W. C., *J. Amer. Med. Ass.*, 1924, LXXXIII, 1894
 MELWISSEN, T., and SLOOF, J. P., *Acta Paediatr.*, 1932, XIV, 19
 MILLER, R., and COURTELY GAGE, H., *Arch. Dis. Childh.*, 1930, V, 83
 MOBLEY, J., and ROBERTS, W. M., *Brit. J. Surg.*, 1928-9, 16, LXII, 239.
 ODOEWS, P. N. B., *Brit. J. Surg.*, 1929-30, XVII, 592.
 ODQVIST, H., *Acta Radiol.*, 1937, XVIII, 112
 PATTISON, A. C., *Arch. Surg.*, 1934, XXIX, 907
 PELL, L. W., *Amer. J. Roentgenol.*, 1934, XXXII, 43
 PICCHIO, C., *Radial Med.*, 1934, XXI, 703
 RAVDEN, I. S., PENDERGRASS, E. P., JOHNSTON, C. G., and HODGES, P., *Amer. J. Roentgenol.*, 1930, XXXV, 306
 ROBERTS, R. E., *Brit. J. Radiol.*, 1927, XXXII, 17
 SANDRA, R., *Fortschr. geb. Röntgenstr.*, 1932, XLVI, 576
 SCHINZ, H. R., BAENZIGER, W., and FRIEDL, E., "Lehrbuch der Röntgendiagnostik," Leipzig, 1932
 SPITZENBERGER, O., *Röntgenpraxis*, 1934, VI, 667
 SPRIGGS, L. I., *Quart. J. Med.*, 1925, 6, LXIX, 1.
 THOMSON, A., *Brit. Med. J.*, 1910, II, 949
 TWINING, L. W., *Brit. J. Radiol.*, 1931, VI, 644
 WALTON, A. J., "A Textbook of the Surgical Dyspepsias," London, 1930
 WILKIE, D. P. D., *Brit. J. Surg.*, 1921, VIII, 204
 WILLI, H., *Fortschr. geb. Röntgenstr.*, 1923, XLVII, 188
 WOODBURN MORRISON, J. M., *Arch. Radiol. Electr.*, 1923, XXVII, 353; *Ibid.*, 1923, XXVIII, 72

PART ONE

SECTION III

SMALL INTESTINE, APPENDIX AND LARGE INTESTINE

CHAPTER XV

THE SMALL INTESTINE TECHNIQUE, ANATOMY, AND PHYSIOLOGY

For the purpose of this section the small intestine may be regarded as that portion of the alimentary canal between the duodeno-jejunal flexure and the ileo-caecal junction.

TECHNIQUE OF INVESTIGATION

The small intestine is investigated by the opaque meal. Although the barium enema occasionally leaks past the ileo-caecal sphincter into the terminal ileum this is an undesirable accident in that examination rather than a practical means of investigating the ileum. While the barium meal forms the principal method of investigation, at times some information may be gained by a plain radiogram particularly in small intestine obstruction. Air then forms the contrast medium.

Fluoroscopy and radiography are both of importance in the investigation of the small intestine. Fluoroscopy is of value in the study of its function. By it peristalsis can be observed, and also the passage of the opaque meal along the jejunum and ileum. This is best conducted in the supine position. For the demonstration of fluid levels, the erect posture is necessary.

Radiography gives the opportunity to study the morphology of the gut in detail and a series of radiograms taken at fifteen minutes, thirty minutes, one hour, three hours and six hours after the ingestion of an opaque cream will as a rule show the various portions serially.

ANATOMY OF THE SMALL INTESTINE

The small intestine is arbitrarily divided into an upper portion, the *jejunum* about 8 feet in length, and a lower the *ileum* about 12 feet in length. The *jejunum* occupies the upper left part of the abdomen, below the transverse colon and stomach. The *ileum* lies in the lower right region. Very frequently the lower part of the *ileum* lies in the pelvis, the terminal portion being directed upwards to join the *caecum*.

There is no abrupt change from jejunum to ileum. The transition is a very gradual one. Nevertheless, if a portion of the upper jejunum be contrasted with the lower ileum, marked differences are evident anatomically (and consequently radiographically). The jejunum is larger in calibre, and its mucous membrane bears many plicae circulares closely approximated to each other. The Peyer's patches are few, small and far between. The ileum is narrower, has many Peyer's patches and gradually loses its plicae altogether as the lower end is reached.

The mesentery renders the jejunum and ileum freely mobile, but in spite of this they tend to keep their relative positions in the abdomen fairly constantly.

MOVEMENTS OF THE SMALL INTESTINE

The classic experiments of Cannon on anaesthetised animals with the peritoneal cavity opened and the gut exposed and radiographically in the intact animal showed three types of movement—rhythmic segmentation, true peristaltic waves and pendulum movements.

The segmentation is supposed to occur first, after the gut has been filled. A series of annular contractions occurs dividing the contents into discrete masses. In seven to ten seconds a second series appears, splitting these boluses the halves joining with their neighbours. The function of this is supposed to be thorough admixture of the food with the intestinal juices. When this has proceeded for upwards of half an hour peristalsis is then said to occur driving the food slowly down the small intestine, at the rate of an inch or two per minute.

Radiological Features—Radioscopic investigation in the human subject after a barium meal shows a very different picture. The movements are seen to vary to a great extent in the jejunum and ileum.

THE JEJUNUM shows a state of restless activity. Pendulum movements are never seen. As soon as the first bolus of the opaque cream passes round the duodenum and over the duodeno-jejunal flexure it is swept rapidly through the first few coils of the jejunum and at the same time assumes a finely fragmented state. As succeeding portions of the meal are delivered by the duodenum those that have gone before are driven by peristaltic waves farther down the jejunum until most of that portion of the intestine is flooded with barium cream in a fine state of subdivision (Fig. 152). The onward progress of the meal is the result of peristalsis but of a much more rapid and vigorous nature than was described by the experimental workers.

The fine fragmentation of the contrast medium is at first sight perhaps puzzling but becomes clear on a consideration of living anatomy of the jejunum. If a large bolus be observed entering the jejunum, the gut is momentarily distended and a homogeneous shadow appears sharply indented by the plicae circulares. This distension however at once stimulates a peristaltic wave and on the passage of this wave the gut regains its normal degree of patency.

namely a state sufficiently collapsed to throw the plicae and mucosa into a fine rugosity the interstices of which are filled with a thinly spread layer of intestinal contents. The muscularis mucosae plays an active part in this "plastering" of the mucosa and the radiographic effect is to produce a uniform mucosal relief pattern. The physiological object of this is obvious—to obtain intimate mixture of the food and intestinal secretions and the subsequent absorption of the food when digested. The rapid peristaltic transit of the meal down the jejunum likewise aids both processes by bringing into use as large a surface of jejunal mucosa as possible.

In individuals in whom gastric evacuation is very rapid the jejunum has to accommodate such a large quantity of the contrast medium that fragmentation is unable to take place at first and a considerable length of the jejunum may show a more or less homogeneous shadow but this overloading is probably much rarer in ordinary circumstances since a plain barium cream passes out of the stomach much more quickly than ordinary food. After gastrojejunostomy and partial gastrectomy it normally occurs to a marked degree.

THE ILEUM—As the opaque medium reaches the ileum a gradual change in the X-ray appearance takes place. The peristaltic activity is slowed down, and the rate of transit diminished. As the rugosity of this portion of the



FIG. 107.—Prone view of the normal duodenum, jejunum and ileum two hours after an opaque meal.

small intestine is much less and the plicae progressively fewer in number fragmentation of the ileal contents does not take place. It is here however that segmentation activity can be made out to some degree and this is the more clearly seen the nearer the ileo-caecal junction is approached. These two movements—peristalsis and segmentation—are difficult to make out fluoroscopically because of the close apposition of the ileal coils. The terminal ileum often lying separate from the remainder of the ileal coils is the least active part of the small intestine. It is typically a more or less straight segment running upwards and outwards from the pelvis to the ileo-caecal junction. By careful observation under the screen slow segmentation can be made out in this portion and at infrequent intervals a peristaltic wave ejecting a bolus of chyme into the cæcum.

Morphologically the TERMINAL ILEUM shows many minor variations in disposition and contour. Care should therefore be exercised in pronouncing any given appearance as pathological. Its mobility in itself and its mobility relatively to the cæcum and appendix should be carefully noted. Its absolute immobility depends on the length of its mesentery and usually decreases in degree as the ileo-caecal junction is approached. It should be borne in mind that the mesentery may virtually disappear in the last few inches of the ileum in which case that portion will be relatively immobile. The terminal ileum should also be mobile relatively to the cæcum and appendix. Fixation to either of those shadows is worthy of suspicion.

The terminal ileum is best investigated at the sixth or seventh hour after the ingestion of a barium meal and is most accessible to palpation with the patient supine. Occasionally even in that posture it and the cæcum are so deeply situated in the pelvis as to be beyond the effective reach of the manipulating hand. In such case the cæcum may occasionally be coated from the pelvis by the Trendelenburg or knee-elbow position.

RATE OF TRANSIT THROUGH THE SMALL INTESTINE

This is so variable that no exact figures can be laid down. Fortunately it is of little importance except for the question of ileal stasis.

The average time for the head of a barium meal to reach the ileo-caecal junction is one and a half to two hours. According to *Hurst* the small intestine should be clear four hours after the completion of gastric evacuation. This time is often exceeded and it is not uncommon to find the last few inches of the ileum filled with barium seven hours after a meal and more than four hours after the stomach is empty. The amount of the gastric residue should be taken into account as well as the time factor in the assessment of ileal stasis.

THE GASTRO-ILEAL REFLEX—When food enters the stomach the terminal coils tend to empty into the cæcum. This was described by *Hurst* under the term gastro-ileal reflex. It is an index of the close association between

these two portions of the alimentary canal, and is said to be inhibited in chronic appendicitis. It has its pathological counterpart in the "ileo-gastric" reflex of *Barclay*. In this connection *Barclay* noted gastric stasis in cases of disease in the region of the terminal ileum. The inference is that a lesion in the right iliac fossa, such as a chronic appendicitis, if it be causing ileal stasis, produces a reflex closure of the pylorus as soon as the ileum becomes filled with food, and thus slows down the rate of gastric evacuation in its later stages.

THE ILEO-CÆCAL VALVE

This valve is really a sphincter, according to *Keith*. It is responsive to peristalsis of the terminal ileum, when it opens, and is said reflexly to close—or exhibit achalasia—in response to the stimulus of a chronic appendicular lesion. Its competency as a valve to the pressure of a barium enema is very variable; in at least 50 per cent of cases it is incompetent, and the opaque enema passes freely into the ileum.

It has been suggested that this incompetence is pathological, although in what exact way it is not quite clear. Indeed, one surgeon devised an operation to fashion a new valve to prevent regurgitation—an interesting example of surgical carpentering gone mad, to the exclusion of all physiological considerations.

In the writer's opinion competency or otherwise of the ileo-cæcal valve is of no clinical nor diagnostic significance whatever.

CHAPTER XVI

DISEASES OF THE SMALL INTESTINE

MECKEL'S DIVERTICULUM

THIS IS AN IMPORTANT STRUCTURE SURGICALLY. IT IS A CONGENITAL ABNORMALITY RESULTING FROM THE PERSISTENCE OF THE INTRA ABDOMINAL PART OF THE VITELLINE DUCT. IT USUALLY SPRINGS FROM THE CONVEX OR ANTERMESENTERIC BORDER OF THE ILEUM SOMEWHERE WITHIN 2 FEET OF THE ILEO CAECAL JUNCTION. IT OCCURS IN 2 PER CENT OF SUBJECTS.

Varieties.—The normal process of obliteration of the vitelline duct may be arrested at any stage. The diverticulum may be a blind-ended patent tube, a fibrosed cord connecting ileum to umbilicus, a combination of these two or it may form a fistulous opening at the umbilicus. The complications which may arise from this abnormality are several, including acute diverticulitis, intussusception, volvulus or strangulation of small intestine by the diverticulum acting as a band. Patients are frequently sent to the X-ray department for investigation of a possible Meckel's diverticulum, but it is frequently impossible to demonstrate the condition radiographically. A positive diagnosis of Meckel's diverticulum can be made only when the diverticulum is seen filled with barium and so disposed as to demonstrate both the blind end and the connection with the ileum.

Apart from this, radiology can afford help in two complications—chronic obstruction resulting from band-like action and fistulous communication of the umbilicus. In the former the approximate site of the obstruction can be demonstrated but not the cause and in the latter injection of the fistula with a barium cream will show its connections clearly.

ACQUIRED DIVERTICULA

Acquired diverticula of the small intestine are not uncommon. They consist of protrusions of the mucosa through the muscularis at the mesenteric border and are usually multiple and tend to develop particularly in the ileum. They vary in size from a pea to a hen's egg.

These diverticula have little clinical significance. They rarely become inflamed or give rise to symptoms. The chief radiological importance they have is in differential diagnosis for in the erect positions they may give rise to fluid levels in a radiogram.

The radiographic features vary according to posture. If the patient be recumbent the diverticula appear after a barium meal has reached the small in-

testine as rounded shadows (Fig. 153). In fortunate circumstances the narrow communicating neck may be seen and the nature of the condition clearly established.

As some gas tends to collect in these diverticula in the erect posture fluid levels are often visible between gas and fluid contents or gas and barium if a barium meal has been given and it is only in connection with these fluid levels and their interpretation that jejunal and ileal diverticula have any importance.

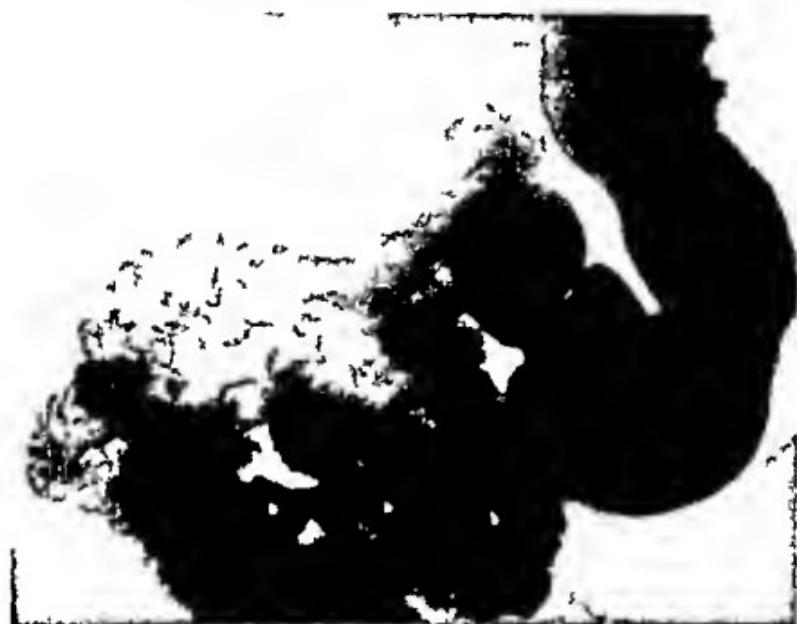


FIG. 153.—M. Ileal Jejunal diverticula (D).

radiologically. The presence of fluid levels is an important radiographic feature of small intestine obstructions and must be distinguished from those of diverticula. The differentiating feature of the diverticular type is the globular nature of the combined air and fluid shadow and its small size. The main portion of the bowel is seen to be normal in calibre and mucosal pattern and the demonstration of the diverticular necks is decisive.

FISTULÆ IN CONNECTION WITH THE JEJUNUM AND ILEUM

The radiographic demonstration of external fistulae of the small intestine is as a rule simple.

All that it is necessary to do is to mark the opening of the fistula with a wire ring, inject a little barium cream through the fistula and

bution in the abdomen under the fluorescent screen. Stereoscopic radiograms are sometimes of value in showing the ramifications of the sinus and its connection with the bowel (Fig. 154).

Internal fistulae are more difficult of elucidation unless the communication be with a viscous other than the small intestine e.g. stomach, colon or gall



FIG. 154.—Double external and single internal fistula of the small intestine following appendicitis. On injecting an opaque cream into the lower sinus (I) the cream outlined the small intestine escaped from the upper sinus () and ran tracked along towards the cæcum.

bladder. If the fistula be between high jejunum and low ileum a barium meal might give a clue by showing the short-circuiting of a large portion of the intestine but a negative result would obviously be of little significance in this connection.

OBSTRUCTION OF THE SMALL INTESTINE

Acute Obstruction of the small intestine is a surgical emergency and as such rarely reaches an X-ray department. Of recent years however mobile

ward X-ray apparatus has made it possible to X-ray such cases quickly and without disturbing them, and information may be obtained, by a plain radiogram taken in this way, as to the site of the obstruction. Needless to say, no contrast medium may be given, but the gas present in the gut above the obstruction is often sufficient for this purpose. In obstruction of the small intestine the gas filled dilated coils above the block are visible, while the colon is collapsed. Some idea of whether the block is high or low in the gut may be obtained by the number of distended coils.

Patey and Ascroft have drawn attention to the different pattern made by the various sections of the intestine in a state of acute distension. This may be a help in determining the site of an obstruction since they may be visible in a plain radiogram. Fig. 155 shows the appearance in isolated coils. The first 10 feet of the jejunum shows a regular and complete cross hatching, from the shadow of the stretched pliæ. The ileum shows no sign of pliæ. The colon presents an outline returning some trace of haustration while the pliæ are incomplete and tend to interdigitate.

In acute obstruction the erect posture is rarely possible. Occasionally the patient may be raised on a tilting table, but to demonstrate a fluid level satisfactorily the perpendicular must be attained and a more practical method of demonstrating these levels is with the patient horizontal and in the right or left lateral position. The radiation is horizontally directed, and postero anteriorly relative to the patient, with the film in front.

Chronic Obstruction—It is however, in chronic obstruction of the small intestine that most information can be obtained for in it a barium meal may be given and the state of affairs more clearly made out.

A note of warning must be sounded regarding the use of the barium meal in these cases. Only if it is quite certain that the obstruction is chronic and



FIG. 155.—Plain radiogram of isolated coils of intestine distended with air to show typical distension pattern of different segments of intestine: jejunum, ileum, transverse colon, pelvic colon from above downward.

not acute dare one give a barium meal. Further, if the chronic obstruction turns out to be colonic, disaster may result. In such case, inspissation of the slowly moving column of barium may convert a chronic obstruction into an acute one. It is therefore safer first to make a barium enema examination to exclude colonic obstruction. Having done so the meal may then be given to investigate the state of the jejunum and ileum.

RADIOGRAPHIC APPEARANCES—In the *erect position* horizontal fluid levels form the most striking feature of small intestine obstructions (Fig. 156). In



FIG. 156.—Obstruction of terminal ileum from adhesions. Radiogram in erect position showing multiple fluid levels.

relief pattern. The plicae being stretched with the dilatation lose their normal sinuous reduplications. This straightening of the plicae is the deciding point in the estimation of obstructive jejunal distension.

A rough guide as to the site of the obstruction is given by the number of distended coils and the extent to which they fill the abdominal cavity. If the obstruction be colonic the small intestine obstruction is as a rule less and a vicious distension of the colon fills the picture literally and metaphorically.

The degree of peristaltic activity as seen on screen examination varies according to the degree and duration of a chronic obstruction. If marked

plain radiograms this fluid level is rendered visible by the collection of gas above it. If a barium meal has been given, the barium filled coils are also seen. The length of these gas fluid levels is variable and the large size of some of them serves to distinguish them from the shadows seen in diverticula. Occasionally gas and liquid faeces in the ascending and transverse portions of the colon may present fluid levels but these are usually limited by haustral contraction and their colonic distribution is usually clearly apparent.

In the supine or prone position the dilated barium filled coils give a characteristic appearance (Figs. 157, 160). A ladder pattern may be assumed by the coils and the mucosal relief pattern of the coils themselves is very typical. The lumen is widened and the barium coated plicae cause a close cross hatching in the mucosal

atony is present, peristalsis is not evident, but as a rule some degree of hyperperistalsis can be seen.

In some of these cases a hypogastric splash can be elicited on clinical examination. Under fluoroscopic palpation in the supine position the actual



Fig. 157.—Duodeno-jejunal flexus from obstructing band (Prone view).

coil in which the splash occurs can be determined. This, when obtained, is an important sign, and one practically pathognomonic of chronic obstruction.

HERNIAE OF THE SMALL INTESTINE

The presence of a loop of the small intestine in a hernial sac can as a rule be demonstrated by a barium meal examination. This is best seen in the inguinal variety when the barium filled loop is observed descending into the scrotum. In the femoral type it is seen in the upper inner part of the thigh, and in the ventral hernia a lateral view shows the barium filled gut in the sac. It is advisable to employ this method for the demonstration of incarceration for fear of overloading the loop with barium and so precipitating a strangulation. In cases of strangulation it is obviously not only inapplicable but actually dangerous.

TUMOURS OF THE SMALL INTESTINE

The small intestine is rarely the site of neoplasms, either benign or malignant.

Of the innocent tumours the least uncommon are the adenomas either



FIG. 1-8. Mechanical obstruction with jejunal dilatation. Front view showing typical cross-hatching.

solitary or multiple. Still rarer are fibroma, lipoma and myoma. All types tend to become pedunculated.

Whilst in theory they should when they obtain a moderate size be demonstrable in a barium meal examination in practice they give no clinical hint of their existence until they cause intussusception or obstruction when the radiographic picture is that of the complication.

CARCINOMA of the small intestine is usually situated in the lower ileum and tends to form an annular constriction leading to obstruction. *Hobart*

has reported a case of non obstructing carcinoma of the jejunum which showed, with the barium meal, a solid filling of the affected segment, with absence of any mucosal pattern therein, and without any dilatation proximal to the lesion.

SARCOMA usually occurs in early life and shows less tendency to stenosis of



FIG. 159.—Chronic obstruction in the small intestine from a carcinoma of the cecum. The ileum is grossly dilated and on clinical examination a marked hypogastric splash could be elicited.

the bowel than does carcinoma. It sometimes becomes pedunculated in the early stage.

CHRONIC ILEITIS

Tuberculous Ileitis occurs in two forms, ulcerative and hypertrophic.

The ulcerative type is usually secondary to an active tuberculosis focus elsewhere e.g. the lungs. The disease begins as an ulceration of the Peyer's patches in the lower ileum. The ulcers tend to spread in an annular direction, and subsequent cicatrization produces multiple stenoses of the gut. It is in this latter stage that it gives radiographic evidence of its nature.

filled lumen is seen to be irregularly contracted, the contracted areas remaining constant on repeated examinations. As the obstruction becomes more marked, the bowel above develops the picture of chronic intestinal obstruction already described. Since the radiographic appearances are not exclusive to this condition the diagnosis ultimately rests on the evidence of active tuberculosis elsewhere, the demonstration of tubercle bacilli in the faeces, or the appearances at operation.

The hypertrophic form is described under ileo caecal tuberculosis in the section on the colon.

Plastic Ileitis (syn. Regional ileitis, Crohn's disease) —*Crohn, Ginzburg,*



FIG. 160. Ileal stenosis seen 7 hours after a barium meal—cause unknown.

and Oppenheimer gave a full account of this condition in 1932, a stenosing and plastic ileitis of the last foot of the ileum.

The cause of the condition which usually affects young adults, is unknown.

CLINICAL FEATURES—The terminal ileum alone is involved. The disease begins as a subacute or chronic ulcerative ileitis, and proceeds to stenosis. Fistulae may develop opening into the cecum or colon. The process involves the ileo caecal junction, but not in the first place the cecum, and is most marked at the juxta caecal portion. The course is relatively benign and simulates clinically an ulcerative colitis, with diarrhoea, and blood and mucus in the stools. Some fever may be present, and a tender mass may be felt in the right iliac fossa.

RADIOGRAPHIC FEATURES.—In the pre fistulous stage the barium enema reveals no abnormality but an opaque meal shows a varying amount of ileal stasis and dilatation above the lesion depending on the degree of stenosis. The involved segment itself presents an irregular narrowing of its lumen most marked at the terminal end and an absence of peristaltic waves (Fig. 161).

When fistulae have formed deformity in the colon may be seen from the spread of the stenosing inflammation to the colonic wall. This may cause a



FIG. 161.—Crohn's disease with involvement of cecum. Fistula between ileum and rectum malum transverse colon. X-ray meal after showing narrowed ileum and Stenosis in cecum. The arrow marks the terminal fistula.

filling defect in the ascending colon or sigmoid closely resembling a carcinoma the fistula being accounted a cancerous one. J. L. Kantor in a report on cases noted the presence of spasm of the cecum (Stierlin's sign). In a case seen by the writer (Fig. 162) this contracture of the cecum was partly spastic and partly organic. The barium meal showed marked narrowing due to both factors and a subsequent barium enema the lesser degree of organic contracture the spasm having relaxed. Kantor also noted a string sign in the affected portion of the ileum and points out that this may be double

when a fistula has developed due to barium in the contracted ileum and in the fistulous track.

DIFFERENTIAL DIAGNOSIS—X-ray diagnosis of this condition may be difficult owing to its resemblance to tuberculous and actinomycosis of the ileo-



(a)



(b)

FIG. 161^a Crohn's disease same as in Fig. 161 after a barium enema. (a) shows the initial relaxation (spasm) and (b) the resultant contracture 15 minutes later after the spasm had relaxed. (This case proved histologically and bacteriologically.)

cecal region. When perforation into the colon has occurred it is apt to be mistaken for cancer of the latter viscera. Ulcerative colitis, Hodgkin's disease, lymphosarcoma and chronic hyperplastic appendicitis are mentioned as other conditions which may simulate it and the true nature may be apparent only on the operating table or on histological examination.

CHAPTER XVII

THE APPENDIX

RADIOLOGY PLAYS no part in the diagnosis of acute appendicitis

For years controversy has continued over the radiological diagnosis of chronic appendicitis and no finality has yet been reached

It has followed its clinical counterpart in fashion and out and has in the past too often provided the *pis aller* of the diagnostically destitute. It might almost be said that Mr Punch's advice applies here also! While this is an intentional hyperbole its object is to stress the caution which must be exercised in making such a diagnosis on radiological grounds alone. In a certain percentage of cases the X-ray evidence is sufficiently strong to enable this to be done but more frequently the signs are less frank. When in doubt tend to give the appendix the benefit of it.

TECHNIQUE

The appendix may be demonstrated by the barium meal and by the barium enema. The former is the more generally useful for several reasons. Firstly by the meal the presence of an organic gastric or duodenal lesion is confirmed or excluded. Secondly the presence of ileal stasis from obstructive adhesions may be shown, again the caecum is not usually so distended by a meal as it is by an enema and less chance occurs of the appendix being masked. Appendicitis and caecal stasis are more satisfactorily studied by a meal. The enema if the ileo-caecal sphincter is patulous may flood the ileum and render it impossible to see the appendix. In certain cases where it is desired to test whether an irregularity of the appendicular lumen shown by the opaque meal is constant or whether failure to fill it is due to obliteration of the lumen a barium enema may be of help.

The thorium double contrast enema has the advantage that if successful the caecum is relatively empty and does not obscure the appendix. It is however not always possible to fill the appendix with this method nor to empty the caecum for the collapsed stage. It is particularly useful in cases of retro-caecal adherent appendices in which it is impossible to obtain a profile view.

For the barium enema the writer uses no special variation from the standard opaque cream. Various special media have been advocated such as arrowroot and buttermilk it being claimed that they ensure filling of the appendix in a larger percentage of cases. It is very doubtful whether they have the slightest effect in this respect or that they are worth the trouble of preparation.

According to *Kerley* the *Cambies* technique is successful in visualising the normal appendix in nearly 100 per cent of cases. This consists in giving by mouth three hours after the meal a concentrated saline solution such as Mag Sulph. 1-2 drachms in 3 oz. of water.

Gottheimer's technique consists in giving castor oil twenty four to forty eight hours after taking the barium meal. Filling of the appendix is said to occur in a large percentage of cases a few hours after this procedure. In *Maingot's* hands this was n less successful special technique than *Cambies'*

For the examination of the appendix the meal should be taken in the morning and the stomach and duodenum first investigated. The patient should subsequently be seen at seven twenty four and thirty hours after taking the meal and on subsequent days as necessary.

The seventh hour is of importance in the detection of ileal obstruction and to show the relationship between the appendix and ileum. Sometimes the normal appendix is not filled at the seventh hour but it can usually be seen at the twenty fourth or thirtieth. Examination on subsequent days is necessary only to determine the presence of appendicular stasis.

Careful fluoroscopic palpation of the appendicular region is an essential procedure at each stage. The patient should be supine and the abdomen well relaxed.

The following points require attention during this fluoroscopic examination: the position and size of the appendix, its mobility, the contour of its lumen with particular reference to kinks and stenoses and the presence of tenderness on pressure over its shadow.

In addition to fluoroscopy radiograms should be taken at each stage. Pressure may be necessary to separate the appendicular from the caecal and/or ileal shadows. For this purpose the best instrument is the patient's left hand. The exact position and degree of pressure is easily determined fluoroscopically. The patient is instructed to relax the hand and reapply the pressure several times to make certain that the same separation effect is achieved each time. Then the patient's hand still lying in the same position, the film is placed in position, the pressure reapplied by the patient and the exposure made. The shadow of the patient's hand is nearly always to the left of the caecal and appendicular shadows and does not obscure them.

FILLING AND EMPTYING OF THE APPENDIX

There is doubt as to the precise mechanism of filling. The prevailing view is that filling of the appendix is a passive phenomenon except for relaxation of the sphincter. It occurs with most certainty at the time of maximum filling of the cecum and may be present at any time between two and twenty four hours after ingestion of the meal. If it has not filled in that time it is unlikely that later stages of the examination will find it visible.

The emptying of the appendix is an active peristaltic function. It is sometimes possible to observe the phenomenon of emptying during screen examination—usually in the form of a change in the appearance before firm radioscopic palpation compared with later. In this case the emptying may be the result of direct pressure. Apart from palpation it is not possible to make out any change fluoroscopically. Serial radiograms do however reveal changes in contour indicative of peristaltic activity. A not uncommon appearance is segmentation producing a rosary effect. The importance of



Fig. 163.—Normal appendix.



Fig. 164.—Normal appendix showing a peristaltic wave.

differentiating muscular from cicatrical constrictions is obvious and indicates the necessity for re-examination at successive intervals.

NORMAL APPEARANCES

The classical appearance of the appendix in a barium meal is that of a blind tube 3 to 4 inches in length, 2 to 4 mm. in calibre, and showing a gentle single or double curve (Figs. 163, 165). From this prototype there may be marked variation in many respects. Its length may vary from 1 inch to 9 inches. Its lumen may be represented by a mere thread of barium or be 5 to 6 mm. in width. Quite acute angulations may be simulated in a foreshortened view. The lumen classically uniform in calibre may be slightly narrower towards the base. A more important variation in this respect is that due to muscular contraction. Such narrowings are inconstant.

The appendix should normally be freely mobile on palpation but if the cecum be pelvic in site it may be inaccessible to such manipulation. The

position of the appendix is normally very variable. It is most commonly found lying to the inner side of the cæcum, but may lie behind the cæcum to

the outer side of it, turn upwards to the liver, or hang down into the pelvis. The appendicular mesentery may be very short in which case the mobility of the appendix is restricted.



FIG. 15.—A normal appendix with faecal contents near the tip. The organ was visible only on displacement of the terminal ileum by the operator's glove hand.

cause fibrosis of the submucous and muscular coats. This causes local or general stenosis of the lumen and lessens the peristaltic activity of the organ.

(3) Stasis of the appendicular contents from such stenosis often results in the formation of faecal concretions. These in turn tend to promote further catarrhal attacks.

(4) The peritoneal coat may become inflamed and as a result the appendix become adherent to adjacent structures. It may be adherent in its middle, causing a fixed angulation or by its tip. A typical adhesion is that of the appendicular tip to the adnexa. In the controlling appendix of *Lane* the appendix is adherent to the terminal ileum and acting like a band causes stasis in the ileum proximal to it. It is doubtful if a chronic appendicular lesion causes ileal stasis apart from such mechanical factors.

Radiological Signs of Chronic Appendicular Disease

No one sign is pathognomonic. Almost every one of them is susceptible to two interpretations—as a normal variation or as a pathological condition.

CHRONIC APPENDICITIS

Pathology

For a proper assessment of the value of the various abnormal X-ray signs observed in and round the appendix it is important to have some appreciation of the pathological conditions which may be present.

(1) The mucosa may be in a chronic catarrhal state. If it is edematous the lumen will be narrowed.

(2) Repeated attacks of appendicular catarrh tend to

The probability of an organic change being present increases in direct ratio to the number of these individually dubious signs detected. The probability is further increased if a subsequent examination shows an unchanged radiological picture. In other words constancy in an abnormal feature is an important indication that it represents a pathological change.

Many signs have been described. Among the more inherently reasonable of these are the following:

(1) **NON-FILLING OF THE APPENDIX**—This may be due to fibrotic stenosis of the lumen. The fallacy is that a certain small percentage of normal appendices do not fill and that the healthy appendix fills and empties itself at intervals.

(2) **INCOMPLETE FILLING**—Where only part of the appendicular lumen is filled it is necessary to determine if possible whether this is due to stenosis of part of the lumen or an empty phase in the appendicular cycle of activity. Again part of its lumen may already contain transparent contents.

(3) **APPENDICULAR CONCRETIONS**—Some of these contain phosphorus and calcium and so cast a shadow; the majority are transparent. The former are visible in a plain radiogram and are liable to be mistaken for any of the following: ureteric stone, renal stone, gall stone, phlebolith. The only positive proof of their nature is their demonstration in a barium-outlined appendicular shadow. They cast a lighter shadow than the barium and therefore show in semi relief. Shot from game and barium from a previous meal are easily recognisable. The transparent concretions are composed of impregnated faeces and can be seen only when the appendix is filled with the opaque medium when they show as an oval gap in the appendix shadow (Fig. 166).



FIG. 166.—Chronic appendicitis. The appendix contained a terminal concretion showed an irregular club deformity and was adherent to the cecum.

(4) **IRREGULARITY OF THE APPENDICULAR LUMEN**—To be of organic import an irregularity of the barium-filled lumen must be constant in a series of radiograms. This can be tested at one seance by firm radioscopic massage of the appendix between the taking of two radiograms. Variations due to muscular tonus and peristalsis vary, those due to stenosis do not. Even if this test produces no change it is as well to check it on a subsequent day or by means of the barium enema (Fig. 167).

(5) FIXATION OF THE APPENDIX.—This usually indicates the presence of adhesions and should be tested fairly vigorously as it sometimes requires considerable pressure to dislodge a mobile appendix. This applies particularly to one whose tip lies in the pelvis. Rarely the fixation is due to a short meso appendix.

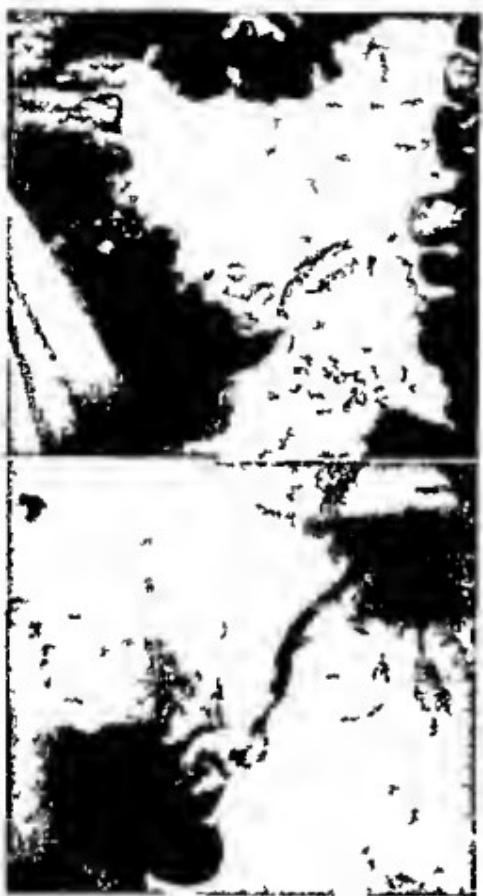


FIG. 16. Appendix adherent at its tip at an hour and a half after the meal. At both examinations the tip was immobile on radioscopic palpation.

(6) FIXATION OF THE CECUM AND/OR ILEUM.—This results from peritoneal adhesions except in the rare cases of anatomical fixation. Two types are worthy of mention. In the so called controlling appendix described by Lane the appendix is adherent across the terminal ileum and not only binds it down to the posterior abdominal wall but causes obstructive ileal stasis. Although Lane regards it as a common occurrence in the writer's experience it is rare (Fig. 169).

A commoner type of adhesion is that of the last few inches of the ileum to the inner border of the cecum. The appendix usually lies somewhere in the angle between these two structures and appendicular inflammation is therefore prone to excite adhesive peritoneal reaction on the two adjacent viscera. The resulting adherence is visible radiographically by the close apposition of the barium filled cecum and ileum even on firm palpation. The appendix may be 'trapped' between them or adherent in front or behind. In any of these situations

it may be impossible to see it until the ileum is empty.

Pathological fixation of the cecum or ileum to palpation is evidence only of peritoneal adhesions. This may or may not be appendicular in origin and has a significance with reference to an appendicular lesion only in the presence of other signs pointing in the same direction.



FIG. 109.—An apendix with a rent across the terminal ileum—the so-called “controlling appendix.”



FIG. 108.—A kinked sigmoid is at the rectal open fissure.

(7) TENDERNESS ON PRESSURE OVER THE APPENDICULAR SHADOW.—This may be a sign of considerable importance and its significance depends on several factors. If the appendix is fixed the tenderness induced by pressure over it probably usually depends on a drag on the parietal peritoneum. Tenderness over a mobile appendix is elicited by deep pressure with one finger accurately over the appendix and should be obtained with the latter displaced into different positions. This tenderness localised over the appendix shadow no matter what its position and over its shadow only forms an important sign of chronic appendicitis. *Hurst* regards it as one of great value and explains the pain elicited as being due to increased visceral tension in the organ. This presupposes some damping back of the contents in the appendix. Whatever the mechanism the sign is the most reliable of all the X-ray evidence.

It must be elicited and localised with careful precision. Vague general tenderness on pressure in the right iliac fossa is of no diagnostic importance. Many patients are sensitive to firm palpitory pressure in the lower abdomen and in these the corresponding area on the left side should also be palpated for comparison.

(8) APPENDICULAR STASIS.—Retention of barium in the appendix after the cecum is clear is regarded by *Kadnka* and others as indicative of appendicular disease. The longer the appendix retains barium the more important is this sign. If it retains barium for three or four days after the cecum is empty of the opaque medium a fibrotic or stenotic



FIG. 170.—Appendicular stasis. Barium residue ten days after a barium meal.

lesion of the appendix is probable. The importance of the sign is obviously enhanced by direct evidence of luminal stenosis and diminished by the demonstration of a normal contour (Fig. 170).

(9) ILEAL STASIS occurs in chronic disease of the appendix if adhesions have formed of such a nature as to cause some mechanical obstruction or if the appendix itself is bound down by adhesions over the terminal ileal loop. According to some authorities it may also result from reflex closure of the ileo-cecal sphincter. Some doubt exists on this point. *Lane* and *Jordan* have made a prolonged study of this and for years ileal stasis was regarded as an important sign of appendicular disease. A tendency also arose to find ileal

stasis where none existed. These authorities attributed the stasis particularly to a kink in the *juxta caecal loop* but this kink is now generally regarded to be much rarer than they held it to be. In the writer's experience it is extremely rare.

In the estimation of ileal stasis there is considerable variation amongst different observers. According to *Hurst* the ileum is usually clear of barium four hours after the stomach is completely emptied but this time factor may be longer in some cases. *Jordan* lays great stress on the fluoroscopic observation of writhing peristalsis in the ileum a phenomenon rarely met with in the experience of others. Dilatation of the last few loops of the ileum may be of significance but again the normal may show considerable variations in this respect.

In the writer's opinion considerable latitude should be allowed to the ileum in the determination of stasis therein and stasis should be diagnosed in the absence of an obvious constricting band only if the evidence is frank i.e. considerable prolongation of the time intervals, considerable retention of barium and definite ileal dilatation.

(10) GASTRO STASIS—*Barclay* has described an ileo gastric reflex in which ileal stasis from disease in the appendicular region causes a reflex inhibition of gastric evacuation with resulting stasis. As gastric stasis can be due to so many other causes its value as a sign of appendicular disease is slight.

In general chronic appendicitis is a condition in the diagnosis of which clinical evidence is as important as the radiological if not more so.

LOCALISED APPENDIX ABSCESS

It is seldom that opportunity presents itself to examine this condition radiologically since the condition usually gives decisive clinical signs. In the more chronic cases however doubt may exist in the differential diagnosis between abscess, carcinoma and tuberculosis of the cecum. These abscesses may vary in size from a hazel nut to an orange or larger. When they reach any appreciable size they cause a pressure defect in the barium filled cecum, may be an irregularity of the caecal outline from associated typhlitis, a fixation of the cecum, spasm of the cecum (*Stierlin's sign*) and tenderness on palpation.

A study of the thorium relief pattern shows the mucosa to be intact. This differentiates the abscess from the other two lesions mentioned above. The colonic mucosa distal from the abscess may show by the same method a state of reflex reaction or irritation.

CANCER OF THE APPENDIX

This cannot be diagnosed radiographically in an early stage. Any radiographic signs present in the early stage are those of an associated appendicular

inflammation When the growth has begun to implicate the ileum and caecum, the radiographic appearances proper to carcinoma in those situations will then show themselves

DIVERTICULA OF THE APPENDIX

These are rare, and occur along with, and part of, a colonic diverticulosis. Theoretically they should be prone to inflammatory changes, being, as they are, blind offshoots from a narrow blind tube but on the other hand *Lockhart Mummery* states that inflammatory changes are rare in them. Cases have been recorded by *Berg*, *Albrecht*, *Kadrnka*, and *Sarazin*. The writer has seen one case, found in a normal appendix during a routine examination.

CHAPTER XVIII

EXAMINATION OF THE COLON

THE FOLLOWING methods are available

- (1) Plain radiogram
- (2) Barium meal
- (3) Barium enema
- (4) Barium-air double contrast enema
- (5) Thorium-air double contrast enema

THE PLAIN RADIogram

The radiogram is used to study the presence and distribution of gas and fluid in the colon in cases of subacute and acute obstruction

THE BARIUM MEAL

The barium meal followed through till the colon is clear is of particular value when the function of the colon requires investigation. Occasionally it is permissible to start this examination seven hours after the ingestion of the meal but in routine work this is undesirable unless it is quite certain the upper alimentary tract is without fault. Convenient intervals for the examination are seven hours after the meal twenty-four hours thirty hours and on subsequent days as is necessary. The examination may extend over a week or longer especially in cases of chronic constipation partial obstruction and diverticulosis. Barium sulphate has a tendency to cake and form seybala if retained too long in a colon and this method should not be employed when there is reason to suspect organic colonic obstruction of any degree. In such a case acute obstruction might be precipitated.

Fluoroscopy and radiography are both essential. The former should be conducted with the patient supine the latter in the supine the prone and sometimes the erect position.

THE BARIUM ENEMA

The barium enema is the sheet anchor in the X-ray investigation of colonic morphology. The barium meal very frequently fails to outline the colon sufficiently for a morphological study. By the opaque enema however the colonic lumen can be completely outlined.

Preparation—There are two desiderata in the preparation for a barium enema—the colon must be voided as completely as possible of its contents faecal and gaseous and the means taken to effect this must not leave the colon so irritable as to prevent reasonable retention of the opaque enema during the examination. Castor oil 1 to 2 oz. is the most generally satisfactory aperient. It should be given on the day before the examination. If the patient is in the habit of taking some other aperient a double dose of that may suffice. If the bowel is not thoroughly cleaned out by this means a small soap and water enema on the morning of the examination may further stimulate evacuation. Usually colonic lavage is necessary. It should be given two hours

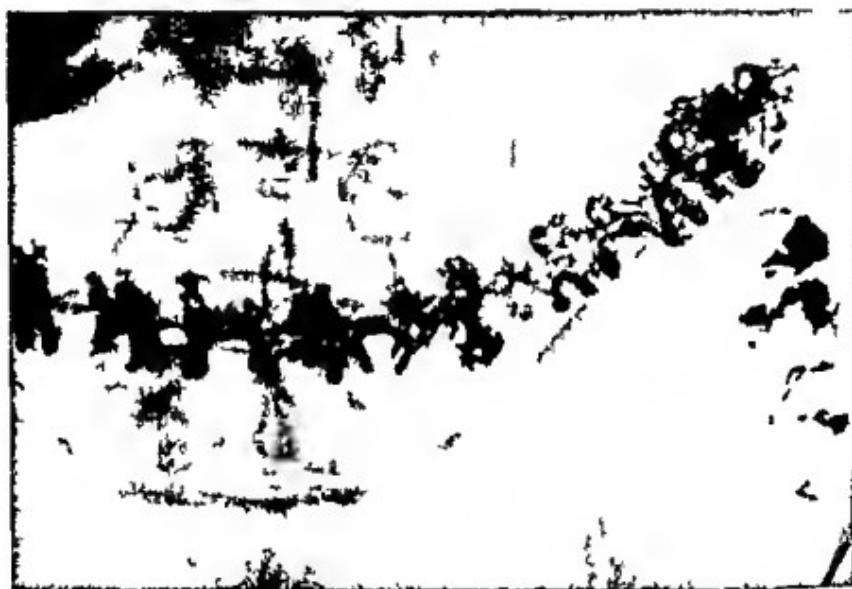


FIG. 171.—Normal colon in rostral pattern 7 hours after a barium meal.

before the examination to allow time for absorption of fluid retained in the upper colon. The Stude chair is the best method for this.

In cases in which there is clinically a strong suspicion of chronic obstruction of the colon vigorous purging is unwise and unpleasant for the patient. It is better then to rely on colonic lavage. The latter procedure will empty the colon as far as the point of obstruction which is all that is necessary for the satisfactory demonstration of the obstruction.

The Opaque Medium—The formulæ which the writer uses are given on page 35. It should be as thin as possible consistent with proper suspension of the barium sulphate. Considerable variation occurs in different brands of barium in this respect. With some specimens the particles are so large that a con-

siderable quantity of mucilage is necessary to hold the barium in proper emulsion, and a thick cream means unduly slow filling of the colon. The colloidal preparations of barium sulphate now on the market will stay in suspension for one half to one hour, and may be used without any suspending agent. They have the advantage that the mucosal pattern is better shown after evacuation and are particularly useful for the three stage barium air enema. The emulsion should be warmed to blood heat before administration. Several pints of cold fluid introduced into a colon is unpleasant for the patient and promotes a peristaltic reflex in the gut. As much as 4 pints may be necessary to fill the colon and this amount should always be available.

Apparatus—The following accessory appliances are necessary.

(1) A large glass funnel capable of holding 2 pints. The usual flat bottomed metal douche-can is not satisfactory as barium tends to form a sludge at the foot. In addition it is difficult to see from it the ratio of administration. An inverted hot water bag with the stopper pierced by a hollow metal tube is quite a convenient reservoir.

(2) Some simple form of stand to support this.

(3) A length of large bore rubber tubing. This is conveniently interrupted by a glass connecting tube.

(4) A strong spring clip or stopcock to control the flow. The stopcock may with advantage be three way, with a side tube for evacuation.

(5) A rectal tube. The opening in this should be terminal or close to the end and large. A large size oesophageal tube serves but some form of metal self retaining enema nozzle is more satisfactory.

It is of vital importance that the whole apparatus of administration be sterilised by boiling or other agent between each examination as the same tubing is used for evacuation of the enema and thus becomes contaminated.

Administration—The patient is arranged on the couch so that the observer is on his left. The rectal tube empties and separates from the rest of the system, is first introduced and the patient placed in the supine position. The tube should be sufficiently long to reach down under the thigh to the patient's side. The reservoir in position on its stand and the main length of tube are then filled with barium down to the glass connecting piece controlled by the spring clip or stopcock. The glass connection is then joined with the rectal tube and the enema ready to be run in. This method involves introducing a small amount of air—the amount in the rectal tube—but this objection is in the main theoretical and the advantage—that of a clean, dry administration—is very practical. Another point in its favour is that the reservoir is not filled until just before the enema is run in and thus the barium has little time to sediment and by so doing clog the tube.

The disadvantage above mentioned may be minimised by placing the glass connecting piece as close to the rectal nozzle as possible. The enema is then run in slowly by gravity the whole process being observed fluoroscopically.

It is important to instruct the patient on three points namely, to make every effort to retain the enema to say if he experiences pain or discomfort, and to give warning of an impending leakage past the tube. A flood of barium on the X-ray couch is quite a devastating occurrence for all concerned (particularly for patient and nurse!) It can be foretold by any intelligent patient its beginnings observed on the screen and its progress arrested by relieving the pressure or emptying the rectum of a few ounces via the rectal tube.



FIG. 17. Barium enema—normal colon appearance.

As soon as the rectum is filled out to its normal wide contour the patient is apt to experience a desire to evacuate. It is advisable then to stop the administration for a few seconds until this passes off. In the majority of patients the whole colon may then be filled without further discomfort but in some intermittent administration is necessary because of recurring distress. Each portion of the gut should be carefully inspected and palpated as it fills and rotation of the patient into the oblique positions is necessary to view superimposed coils in their entirety, particularly in the sigmoid and splenic flexure.

Radio-grams should be taken during the filling if any special point warrants and routine supine, prone and oblique views after complete filling. The patient is asked to retain the enema while these are developed and inspected in case they reveal some point requiring further investigation. Most patients can do this but if any distress is experienced it can as a rule be relieved by emptying the rectum only and without disturbing the general filling of the colon. The enema is then run off as far as possible. Usually only a portion can be returned in this manner. This process can be aided somewhat by pressure on the hypo-

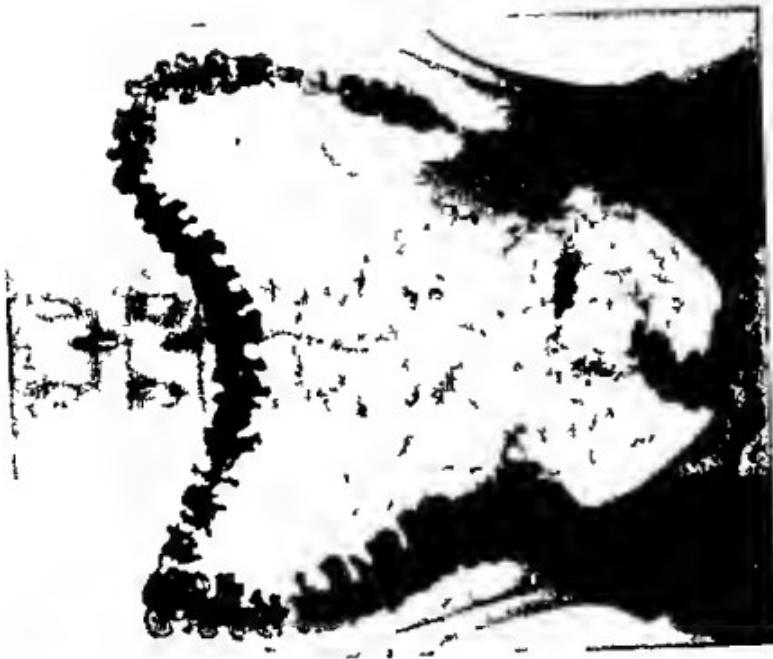


FIG. 173.—The same, after evacuation of the exudate. The epithelium prevented an Indian club deformity and was the seat of chronic inflammation

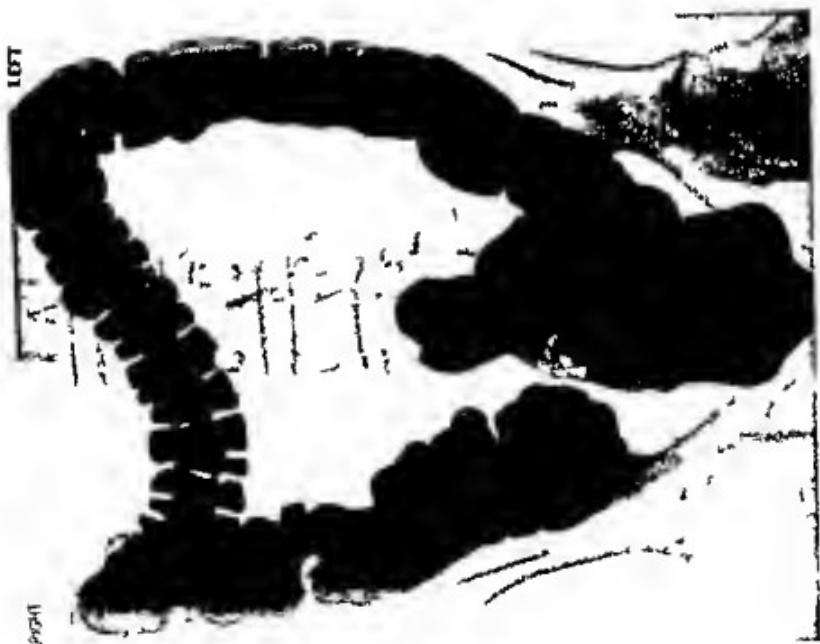


FIG. 173.—Normal conjunctival appearance

gastrium. A further radiogram may then be taken or after the patient has retired and relieved himself in the normal manner. The mucosal pattern



FIG. 10.—Normal colon after evacuation of a barium enema. This特别仔细的 photograph shows the appearance in the three stages of a barium enema, from cecum to sigmoid, seen 1. the initial pattern of collapse, 2. the contour line in inflation, and 3. the barium-filled meniscus.

may sometimes be seen at this stage but in many cases no satisfactory view of it is obtained.

THE BARIUM AIR DOUBLE CONTRAST ENEMA

This may give an excellent picture of the normal colonic mucosal pattern but is rather a long process and is not always successful. The appearance of

the normal place is similar to that described later in the thorium three-stage enema, but the abnormal place are more erratic in their demonstration than with the latter medium. Frequently the barium fails to coat the mucosa completely. The method is of particular value in the demonstration of small pedunculated growths. *Kirillin* recommends its use on all cases of colonic haemorrhage in which the ordinary barium enema has failed to reveal any organic lesion. The technique, as evolved by *Kirillin*, is as follows:

The preparation is all important, and must ensure complete evacuation of the bowel. Two ounces of castor oil should be given on the day before, and on the morning of the examination saline colonic lavage is given until the return is clear.

After the ordinary barium enema examination has been completed the patient retires and empties the bowel as far as possible. On his return, a radiogram is taken of the collapsed bowel in the hope of showing the mucosal pattern. There is more chance of this being achieved if the "colloidal" preparations of bismuth are used. The colon is then filled with air by a Higginson's syringe. This in turn induces a call to stool. The patient again retires and the process is repeated until all the barium has been evacuated except for a thin layer coating the mucosa. Two or three insufflations may be required to effect this. After a final air inflation stereoscopic radiograms are taken. These show the gas distended colonic walls standing out in relief and a barium coated polypoid tumour can clearly be seen projecting into the lumen. A scybala presents a closely similar appearance, hence the necessity for very thorough preparation.

THE THORIUM-AIR DOUBLE CONTRAST ENEMA

Because of its simplicity, the bismuth sulphate enema remains the standard method of examination of the colon, but in certain cases of difficulty an investigation of the mucosal pattern by flocculent media may be helpful. This is a variant of the barium-air double contrast enema method described above, and the examination in this case is also in three phases: (1) the filled colon, (2) the collapsed colon showing the mucosa coated by flocculation of the opaque medium, (3) the colon distended by air.

The difficulty at the age of bismuth sulphate for this purpose is that flocculation does not occur, and the coating of the mucosa is very incomplete. The labile colloidal suspensions of thorium oxide if used with proper technique, deposit themselves more satisfactorily on the surface of the mucosa and so outline it. Three preparations are available, so far—*collotor*, *umbrather* and *diagnothorine*—and all three have a common characteristic in that they are rapidly precipitated or flocculated by ordinary water. Thorotrust, being a stable form of thorium dioxide, does not flocculate and is unsuitable for this purpose. Flocculation should not take place too rapidly, otherwise the deposited layer may be too thick, not sufficiently elastic, and the upper reaches of the colon not

reached. It depends on two factors, the exact preparation itself, and the pH of the colonic interior.

Briefly, a high pH induces the deposition of an elastic layer, which readily stretches during the subsequent insufflation, while a low pH produces a flocculent layer less viscous and more apt to fragment during insufflation. In theory, it might be possible to choose a medium suitable to the ascertained pH of the colonic contents in each case. In practice it is simpler to adjust the latter to the medium, during the preparation of the patient by the use of colonic lavage with a solution of sodium phosphate in a strength of 10-20 per thousand. The above three media act best, on the average where the colon has been washed out one hour before with this solution. Diagnothlorine, the medium used by the writer is sold by the makers in a strength of 25 per cent and should be diluted to the appropriate strength for use (5-10 per cent) with distilled water. Tap water will cause an immediate precipitation.

Preliminary Preparation—Because of the biophysical factors involved, this is of the utmost importance. The colon must be completely emptied of all scybala and other contents and the mucosa cleansed of adherent mucus etc., and its pH adjusted.

Maingot recommends the following preparation:

(1) On the evening before the examination 1-2 oz castor oil followed by a liquid diet up to the time of the examination.

(2) On the morning of the examination colonic lavage with plain water two hours before and with the above solution of sodium phosphate one hour before.

Saline purges and drastic cathartics are inadvisable, since they irritate the colon and cause hyperemia and hypermotility of its mucosa. Even castor oil does this to a slight extent.

The Injection—The essence is to use as little of the opaque medium as possible. Distension of the colon is to be avoided. The administration must therefore be intermittent. *Maingot* and his co workers use a special air pressure apparatus delivering a full strength or half strength solution at will. In the absence of such apparatus the solution may be administered by gravity using a glass funnel and tube or by a Higginson's syringe. Whichever method is used about half a litre is sufficient to fill the whole colon. The filling should be observed fluoroscopically and not more than 1-2 oz injected at a time. One must avoid distending the rectum as it may not contract satisfactorily and so retain too much of the medium. In this examination it is undesirable to stretch the tonicity of the colon. Usually the colon fills satisfactorily as far as the right half of the transverse colon, but it is often difficult to fill the right colon. Any attempt to increase the pressure of the injection must be resisted. Turning the patient on the side and on the face may be successful. Palpatory pressure should be guarded against, lest a mass peristaltic wave is induced.

When the colon is filled to the cecum, but with its lumen relatively con-

tracted the first radiograms are taken. The patient should then be still for ten to fifteen minutes to allow flocculation to take place. He is then instructed to empty the rectum but not to strain. It is preferable to pass two or three visits to stool since it is said by *Maingot* straining may induce secretion of colonic mucus and displace the flocculent layer. As soon as the bowel is collapsed there is not a minute to lose since mucous secretion quickly begins to displace the flocculation. The necessary radiograms should be taken at once and then the third phase air distension may be undertaken.

Failures in the Technique of Flocculation

No deposition may take place at all. In this case it is best to postpone re-examination to a subsequent date to repeat the preparation with thorough care and to use a stronger colloidal suspension. Immediate refilling with a stronger suspension is less likely to be successful.

IRREGULAR DEPOSITION—Flocculation may take place say in the right colon and none in the left. Further measures will depend on the diagnostic requirements. It may be possible to proceed to immediate partial refilling with stronger suspension as in the case postulated. In some cases the partial flocculation may give the necessary information while in others complete refilling on another day may be advisable.

FAILURE TO EVACUATE—The evacuation of the colon may be incomplete. This is prone to occur in elderly subjects and the right colon is commonly the site of the incomplete emptying. Posture and abdominal massage may help but are sometimes ineffective. Pitressin (5 units) is sometimes effective but may provoke vigorous segmental peristalsis and destroy the mucous pattern. Prostigmine may promote satisfactory peristalsis and in elderly patients and others in whom colonic atony is suspected 1/2 cc of prostigmine may be given hypodermically with advantage twenty minutes before the beginning of the examination.

Insufflation of the Colon—As soon as satisfactory radiograms have been obtained of the collapsed mucous pattern the colon should be insufflated prior to the final radiogram. This should be done under fluoroscopic control. An arterial pneumothorax apparatus gives a carrement filling but a *Higginson's* syringe manipulated gently is a satisfactory substitute.

Certain difficulties may be met with during insufflation. Ideally the whole colon should fill regularly from rectum to caecum but in most cases there is some variety in the distribution of gas and some of the opaque injection retained. With this one must be content.

In hypertonic strongly muscled subjects it may be difficult to distend the colon satisfactorily. If the sphincters are patulous retention of the injected air may be impossible although the use of a large rectal tube may help in this respect.

Radiographic Appearances in the First Stage, that of the Filled Colon — These are substantially the same as with a barium enema save that the colon is not so distended and the medium not so opaque (Fig. 176)

Radiographic Appearances of the Plicæ in the Second Stage, after Collapse of the Colon — A colon will contract by virtue of its elasticity and muscular



FIG. 176 Normal colon in a three-stage enema. First stage of filling.

tonicity. The narrowed lumen has to accommodate the same mucosa and the latter folds itself into plicæ (Fig. 177)

Types of Plication

(1) *Haustrations* the whole wall being involved

(2) *Mucosal Plicæ* — The mucosa is very laxly attached to the muscular coat and can form varying plicæ independently of the latter. The plicæ are produced by the activity of the muscularis mucosæ and their form varies with the degree of vascularity of the submucosa, the secretory activity of the mucous glands and other nervous and irritative factors.

Pilocarpine contracts the gut and increases the number of plicæ. Atropine has the reverse effect.

Form of the Plicæ

Longitudinal folds tend to take place when the tenia are relaxed and the gut lengthened. They are common in the lower sigmoid. *Transverse plicæ*

occur when haustra are present. Usually both can be made out, and from these primary plicae secondary arborisations frequently arise (Fig. 171). As in the stomach, so in the colon great variation in the normal mucosa may occur, and in the present state of our knowledge diagnosis of the pathological should be guarded.

Pathological Variations in the Mucosal Pattern.—The plicae do not form at all unless the colon contracts and empties itself. At times collapse does not



FIG. 177.—Normal thorium air enema. Second stage, of collapse.

occur—air in the colon prevents it; atony or hypotonia of the colon above an obstruction, and rigidity of the colonic wall are other causes. Assuming that collapse has taken place and the opportunity for flocculation and plication so provided, certain variations in the mucosal pattern may indicate pathological states. Amongst these variations are the following:

PLICÆ SMALL AND NUMEROUS.—This is seen in the so-called "irritable" colon, a condition which *Knothe* describes as a reflex disturbance of the neuro-muscular mechanism, e.g. from tuberculous peritonitis, cholecystitis, or appendicitis.

PLICÆ LARGE AND FEW IN NUMBER.—This results from any congestion of the mucosa, as in catarrhal coitis.

PLICÆ SMALL, SIMPLE IN PATTERN, AND FEW IN NUMBER.—This occurs with atrophy of the mucosa.

Of greater diagnostic importance than the above are certain other changes in the mucosal pattern such as

ASTERISK OR HONEYCOMB PATTERN in polyposis. The clear interstices represent the polypi. In diverticulitis a similar star pattern may radiate from a filled diverticulum.

DISORGANISATION OF THE PATTERN—This is seen in mucous colitis and in increased degree in early ulcerative colitis.

ABSENCE OF PLIAGE—This results from grave destruction of the mucosa as in advanced ulcerative colitis or neoplasm.

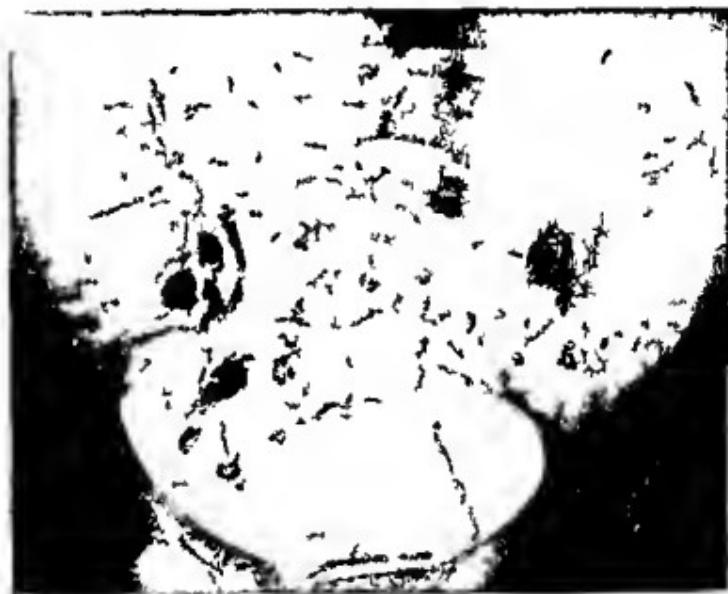


FIG. 18 Normal thorium enema. Third stage of inflation.

Radiographic Appearances of the Third Stage after Inflation of the Colon with Gas—Three aspects in particular should be noted—the colonic calibre, the delineation of its contours and the appearance of the anterior and posterior walls seen *en face* (Fig. 178).

THE COLONIC CALIBRE when insufflated is between two and three times that when filled by the thorium enema and about equal to or a little larger than that shown by the ordinary barium enema. The variations from the normal are similar to those shown by the barium enema and need no further description here.

THE CONTOUR LINE is of considerable importance according to Maringot. Normally if the flocculation and distension have been successful the contour of the lumen should be outlined by a dark line 1-2 mm. thick, uniform and

continuous. Mangot and his co-workers lay such stress on this that they have named it the *hière mucosae de sécurité*, on the hypothesis that if this line is present in unbroken continuity it excludes an ulcerative colitis. Its absence is of less importance since defective flocculation or excess of mucous secretion may prevent its appearance or rapidly obliterate it, respectively.

The opaque contour line may be quite absent in mucous colitis but more commonly it is broken, appearing like Morse code symbols. This also is inconclusive as a sign and may appear in the normal subject if the flocculent layer was too inelastic to accommodate to the stretching of the insufflation.

Again the marginal line may be irregular or woolly, due to excess of mucus in it. In diverticulitis it shows a characteristic appearance described under that section. In intrinsic tumours and developed ulcerative colitis the line is irregular and broken at the site of the lesion.

THE SURFACE OF THE MUCOSA SEEN 'IN PLACE' in the area bounded by the contour lines ('intermarginal area') also merits attention. Normally it should be uniform like a colour wash, if the flocculation has withstood the insufflation. More commonly it cracks, and forms a mosaic, like the "crazing" in pottery ware. In this mosaic the "stones" are opaque and the intervening cement is transparent. In this intermarginal area various opacities may be visible such as the rounded shadows of filled diverticula and the irregular blobs of impregnated mucus in mucous colitis.

Reticulation may be evident, the appearance then being the negative of the normal crazing, i.e. the reticulum is opaque. It is irregular in type and is seen in developed ulcerative colitis with granulomatous proliferations.

Polyposis shows a remarkable "negative" mosaic appearance, the clear spaces representing the polypi. Larger ones may retain a complete coating, and stand out clearly in the air filled colonic lumen.

Carcinoma shows a completely disorganized irregularity in the intermarginal shadows, and the unchanging quality of this deformity is an important feature.

In conclusion the thorium three stage enema is a new method, and is not infrequently unsuccessful. The technique is difficult, but further experience may indicate modifications which will improve the percentage of successful administrations. It appears at present to be of value chiefly in cases of colitis and colonic haemorrhage in which the older methods fail to give definite radiological signs, and its precise value as a method is yet to be finally assessed.

CHAPTER IX

ANATOMY AND PHYSIOLOGY OF THE COLON

ANATOMY OF THE LARGE INTESTINE

THE LARGE intestine consists of the caecum the colon and the rectum. Its anatomy and general arrangement in the abdomen do not need detailed description except for some points of radiological importance. Its average length is 5 feet and its width varies from 2 to 3 inches. The widest part is the caecum and it gradually narrows towards the rectum.

THE CAECUM the widest and most distensible portion with the exception of the rectum is usually situated in the right iliac fossa but it is subject to great variation in this respect depending on the length of its mesentery and the habitus of the individual. In hypersthenic subjects it may be high up in the fossa and in hypothenic deep in the pelvis. It is normally freely mobile on palpation but in about 5 per cent of cases it possesses no mesentery and is then relatively fixed. This variation must be borne in mind in the diagnosis of cecal adhesions.

THE ASCENDING COLON is continuous with the caecum and runs upwards to end at the hepatic flexure. The ascending colon is said to have no mesentery and to be bare of peritoneum posteriorly but in spite of this it displays a surprising degree of mobility. The forward and medial bend of the gut which forms the HEPATIC FLEXURE has no firm attachment above and its position varies markedly with posture. In the erect position it is usually just above the iliac crest and in the supine 1-2 inches higher.

THE TRANSVERSE COLON has a long mesentery and is subject to great variation in position. It may pursue a relatively straight course between the flexures or hang in a pendent loop into the pelvis.

THE SPLENIC FLEXURE occupies a position high under the left dome of the diaphragm. It is in respect of its position the most constant part of the upper colon being anchored there by the costo colic ligament. Occasionally it is seen lower in position but this is held by some to be always pathological. Indeed if there be any true radiological sign of *Glenard's disease* it is marked descent of this flexure.

THE DESCENDING AND ILLIAC PORTIONS OF THE COLON drop down from the splenic flexure to the true brim of the pelvis. As a rule they have no mesentery but in spite of this considerable lateral mobility is normally present. They are the narrowest portions of the colon.

THE PELVIC COLON has a mesentery which when spread out curves the gut

in sigmoid form. This portion is therefore freely mobile, and very varied in its disposition. In some cases the mesentery is short, in others it is long and allows of a large sigmoid loop. At its termination it is directed backwards and then downwards to form the rectosigmoidal junction. It therefore lies in front of the upper part of the rectum.

THE MUSCULAR COAT of the colon is composed of an internal continuous circular layer and three outer longitudinal bands, the *taenia coli*. The tonic



FIG. 179.—Normal colon 7 hours after a barium meal, showing the trefoil arrangement of the haustral pockets, due to the deposition of the *taenia coli*.

contraction of these bands helps to form the haustral sacculations of the resting colon. These haustrations are largest in the caecum and ascending colon, most regularly formed in the transverse colon (where they may be literally geometrical), and gradually disappear as the sigmoid is reached. Each haustral segment is typically trefoil when viewed in cross section (Fig. 179).

FUNCTION OF THE LARGE INTESTINE

The function of the colon with which the radiologist is particularly concerned is, in the main, motor; its method of filling, and its tonic and peristaltic activity.

This is best studied by the barium meal.

Filling of the Caecum and Upper Colon.—In spite of the countless screen examinations which have been made on subjects and patients, this still remains

something of a mystery. A colon is viewed, say, two to three hours after a barium meal, and some of the opaque medium is seen in the caecum. Two hours later, the colon may be filled with barium as far as the middle of the transverse portion, yet repeated screen examinations during that interval would fail to reveal any appreciable movement in the contents of the gut.

The explanation lies, I think, in three factors (1) The regular intermittent passage of small quantities of chyme from the ileum into the caecum (2) The fluid nature of this chyme (3) The tonicity of the bowel

When fluid contents pass into the caecum the tonicity of the latter tends to force them a certain distance along the colon, depending on the amount of fluid and degree of tonicity. This is a very slow process and can be likened to a very slowly administered barium enema so slow that the onward progress of the head of the barium column cannot be appreciated. The process is arrested gradually by the activity of a function of the upper and right portion of the colon—that of resorption of water. As the contents become semi-solid and then pultaceous this onward progression ceases, and a different form of activity takes charge—the mass movement.

Mass Movement—This form of peristaltic activity, first described by Holznecht over twenty years ago, is now accepted as the only normal method of transporting the contents of the upper right colon towards the rectum.

The term "upper right colon" is coined to indicate that portion of the large intestine in which the resorptive process takes place. It extends from the caecum to about two thirds along the transverse colon. The colon from about the splenic flexure to the rectosigmoidal junction is different in function. While the former may be regarded as a reservoir, the latter as Gaskell has described it is a transmitting segment of exaggerated irritability. Its normal state is that of emptiness. Haustral sacculations, the object of which is to increase the area of absorption, are poorly marked in the left colon, where the necessity for them is less. Whenever a faecal bolus is delivered to this portion over the splenic flexure, the tendency is for it to be swept down into the rectum.

To return to the mass movement the sequence of events is as follows: first of all the haustral contractions over a considerable segment of gut, the transverse colon disappear and the barium shadow has a ribbon like outline. This change occurs very rapidly in two to three seconds. At the same time a constriction appears proximal to the faecal mass, usually in the region of the hepatic flexure. Barclay has stressed the importance of this constriction which he terms the *point d'appui*, and is of the opinion that on its competency depends the successful transference of the faecal mass along the colon. The more liquid the mass is the greater the importance of this to prevent reflux into the lax ascending colon and caecum. This constriction really marks the starting point of the strong peristaltic wave which sweeps the colonic contents on towards the rectum. The whole process is over in a short time.

In about ten to twenty seconds the mass may reach the descending or sigmoid colon. The mass movement may be arrested for a few moments when the iliac colon is reached and then continue until the mass is in the rectum.

A few seconds after the reflex is completed haustral contractions reappear, and as *Barclay* puts it the general picture of still life is restored.

Not uncommonly a radiogram taken after a mass movement has taken place will show a snail track of barium along the empty colon along which the transference has taken place. This is a common appearance in cases of mucous colitis—*Crane's* string sign—but occurs also in the normal.

In the perfect physiological reflex the portion of gut involved in the wave should be emptied completely but frequently some fragments are left in the wake. This is particularly apt to happen if there has been a tendency to constipation and formation of seybala.

These mass movements occur infrequently, two or three times a day, and vary in the extent of their travel. Some reach the sigmoid or rectum and some the descending colon the mass left there being dealt with by a subsequent reflex some hours later. Only when the rectum is reached is a call to stool experienced.

Other Movements

THE PENDULUM MOVEMENT OF RIEDER—This observer has described to and fro movements of the contents of quite a large segment of the bowel. The object is supposed to be to churn the contents. It is said to be an established phenomenon but it is extremely rarely seen. The writer has not come across it in thousands of screen examinations although he has observed the mass movement on many occasions.

ANTERIOR PERISTALSIS—*Case* has recorded cases of antiperistalsis in the colon. It is possible that this occurs behind an obstruction in the upper colon and often occurs in a colon which is trying to rid itself of a barium enema against the patient's wishes but it is doubtful if it occurs in the normal apart from such forcible voluntary restraint of defecation.

HAUSTRAL CHURNING—This has been described by *Samson Wright Cole* and others. It occurs especially in the caecum ascending and proximal transverse colon and consists of slow alterations in the degree of the haustration. They are too slow to be detected with certainty on screen examination, but can be seen in serial radiograms.

RATE OF TRANSIT THROUGH THE LARGE INTESTINE

This varies enormously in different individuals and obviously depends on the number and extent of the mass movements which take place in the twenty-four hours. Taking as a standard the subject who defecates once a day, the rate of progress of a barium meal is somewhat as follows:

In three hours the cecum is filled in five to six hours the head of the barium is in the region of the hepatic flexure or proximal transverse colon, in twelve hours it is about the splenic flexure. By twenty four hours half of the barium may have been evacuated and the remainder rather scattered with traces in the cecum and ascending colon and some in the sigmoid. From the distal position of the transverse colon to the iliac colon is usually clear. By forty eight hours none should remain.

In those of more active colonic habit these times may be greatly shortened. It is not uncommon to find barium in the rectum two to four hours after ingestion especially in circumstances of nervous stress. It was *Trousseau* who first drew attention to the tendency to hypermotility and diarrhoea in the neuroses.

A more common occurrence however is to find these times lengthened and while such a state of affairs is often labelled as stasis it is important to bear in mind that that stasis may be physiological.

CHAPTER XX

ANATOMICAL VARIATIONS OF THE COLON

These may be classified in the following manner

- Anomalies of length
- Anomalies of rotation
- Anomalies of fixation
- Anomalies of size
- Anomalies due to adhesions and herniae

ANOMALIES OF LENGTH

The Short Colon, with high position straight gut between the flexures, and a small sigmoid is of little clinical significance since it is seldom associated with physiological dysfunction. The writer's impression is that colospasm is more common in this type than in the hypotonic individual.

The Long Colon, redundant colon, or dolichocolon of the continental writers, is according to Knott, frequently associated with a clinical syndrome consisting of constipation, gaseous distension, and abdominal pain—the auto-intussusception of Arbuthnot Lane (Fig. 180).

Knott describes the following criteria:

The long pelvic loop rises well above the intercrestal line. It may be placed medially, or to the right or left.

The redundant descending colon is commonly coiled or reduplicated, the transverse colon deeply festooned or convoluted and the ascending colon doubled.

The redundant colon can cause considerable discomfort to the patient and trouble to the radiologist if the upper colon is distended with gas, to the former by flatulent discomfort and to the latter by making gastric examination difficult. When distended with gas it can produce the various stages of cascade stomach, bilocularized stomach, and volvulus in both planes.

Subphrenic Displacement of the Colon (*Syn. Hepato-diaphragmatic Interposition*)

Frequently the gas filled transverse colon may be seen, in cases of the long axial gastric rotation crossing in front of the liver, and up between the liver and the right eupola—the so called falciform colon (Fig. 181). Graham Hodgson in a personal communication records a case in which the falciform ligament was found at operation to be absent. This hepato-diaphragmatic interposition may be temporary, or may become fixed. The upward displacement may also be posterior to the liver.

FIG. 181. Anterior half of the hypogastric intercostal
of the colon



FIG. 182. Normal human embryo at approximately six weeks of
age, red ink tract type



A vicious circle may be established in these cases, the gas tends to float the gut up to the diaphragm, and the position tends to prevent the onward passage of the gas. It is possible that patressin might be of help in this condition an important one because of the symptoms produced, the gastric deformity it produces and the way in which it may simulate at times free gas under the right dome.

ANOMALIES OF ROTATION

The most severe degree of failure on the part of the embryonic intestinal rotation is known as—

Situs Inversus Partialis Commune Mesenterium—In this congenital variation the small intestine occupies the right abdomen and the colon the left. Both have a common mesentery, and the colon is very mobile. The liver, spleen, pancreas and stomach are normal. The duodenum instead of curving round to the duodeno jejunal flexure makes a loop to the right and joins the jejunum on the right side below the liver. The ileum lies below the jejunum, in the right iliac fossa. The terminal ileum runs across the midline to join the cecum, the ileo cecal junction is on the right cecal wall. The variable portion of the colon in these cases is from cecum to splenic flexure. A usual arrangement is that the cecum lies near the left iliac fossa anterior to the ileum, the ascending colon runs upwards and bends over into a looped or folded transverse colon. It is as though the right half of the colon has been displaced concertina wise towards the left half, and lies more or less in front of it.

This arrangement may be made out both by a barium meal and enema. Cases of congenital abnormality of this type are said to be more liable to the formation of obstructive bands and kinks than normal individuals.

Etiopathology—This abnormality is the result of a failure of the normal rotation of the gut during early intra uterine life (Fig 182). During the first five weeks of life, the mid gut, supported by the superior mesenteric artery, herniates through the umbilicus into the cord. At the 'aper' of the loop of herniated gut are attached the vitelline artery and duct (the site of Meckel's diverticulum). These divide the gut into pre and post arterial parts. Rotation of the gut begins about the tenth week.

At first the pre arterial segment (small intestine) lies to the right and the post arterial to the left. Rotation occurs with the gradual return of the gut into the abdominal cavity. The pre arterial segment leads and as it returns it passes under the superior mesenteric artery and pushes that part of the post arterial or colonic segment which was not herniated to the left there to form the left half of the colon.

The cecum is the last to be returned. At first it lies in the midline anterior to the small intestine. As the transverse colon develops the cecum travels first to the right hypochondrium and then down to the right iliac fossa. It

may halt in the former position, and represent the variation known as the *undescended cæcum*.

In the abnormality under discussion, the small intestine fails to pass under the superior mesenteric artery, but remains in the right abdomen. There is thus no duodenal loop. Similarly, the cæcum fails to perform its semicircular tour to the right iliac fossa, and remains either in the midline, or just to the left as above described (Fig. 183).

Minor Abnormalities of Rotation—The minor failures result in the *undescended cæcum*. This may be subhepatic—a rare site—but the cæcum more commonly descends to a point where its apex is at the iliac crest in the prone

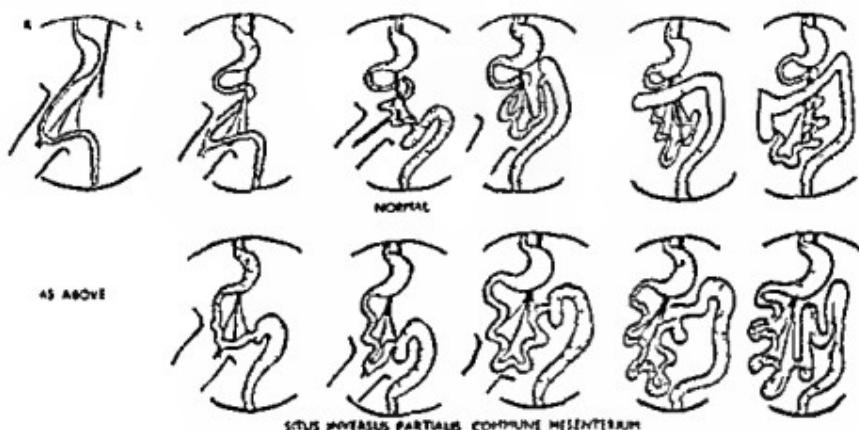


FIG. 182.—Diagram illustrating the development of the normal gut and the gut in situ inversus respectively.

position and in the upper part of the right iliac fossa when erect. It has no clinical significance. Not an uncommon abnormality is the upturned cæcum. Two views obtain as to the aetiology of this ectopia (1) congenital; and (2) adhesions. Doubtless both occur.

Kantor describes a condition of *hyperdescent*, in which the cæcum is in the pelvis in the absence of visceropexy. He states that a clinical syndrome is commonly met with in association with it, reflex vomiting, toxic headaches and dragging pain in the right iliac fossa, and that the appendix is frequently removed in these cases through a mistaken diagnosis of chronic appendicitis.

Transposition of the Abdominal Viscera—It may be important to recognise this interesting congenital variation if an abdominal operation is contemplated. It may or may not be accompanied by transposition of the thoracic viscera. It is of course, very easily recognised on screen examination, but in a radiogram only if the right and left sides of the film have been marked. As this is not usually done in barium meal examinations, a particular record should be made when the abnormality is noted on fluoroscopy.

(b)

(a)

FIG. 163.—Two cases of *situs inversus parvulus* (a) shown by a larva in meal and (b) by a larva in enema



ANOMALIES OF FIXATION

The colon tends to be relatively fixed in hypersthenic individuals, a happy state of affairs in them since it is the other extreme that is associated with symptoms. Coloptosis is bound up with the subject of Glenard's disease each of which must be clearly differentiated from the other.

VISCIROPTOSIS

(*Syn. enteroptosis, splanchnoptosis, Glenard's disease*)

Glenard in 1886 first described this condition as a clinical entity. It is in essence a symptom group associated with laxity of the peritoneal and mesenteric attachments so that the stomach, the intestines, the kidneys, the liver and spleen prolapse to a lower level than that which they normally occupy. The organs most commonly affected are the stomach, colon and right kidney. Radiography has shown that there are three groups of cases in which the abdominal organs are low in position and it is important to differentiate between them.

(a) Normal Individuals of a Hyposthenic Habitus — A low position of the viscera is normal in these subjects and is not inconsistent with perfect health and vigorous athletic pursuits.

(b) Cases in which True Ptosis is present, dependent on relaxation of the abdominal wall from repeated pregnancies or other cause. Frequently an extreme degree of prolapse may exist without symptoms.

(c) True Glenard's Disease — These cases occur in patients of hyposthenic habitus and are especially associated with the neuroses. Such patients are usually thin and lacking in abdominal fat and any factor which tends to impair their general health is apt to precipitate the development of the symptom complex. An essential feature of the disease is the symptomatology. In addition to the general neurasthenic symptoms there are present those referable to the prolapsed organs. Prominent among these are a sense of weight and dragging in the abdomen aggravated by exercise and relieved by lying down and symptoms of nervous dyspepsia such as fullness, flatulence, epigastric discomfort and nausea after eating and sometimes actual pain. Constipation is the rule and there may be an associated mucous colitis.

It is obvious therefore that the X-ray evidence of abdominal ptosis requires the corroboration of the clinical picture before true Glenard's disease can be diagnosed and even if the X-ray signs are present it is unwise to stress them to the patient of neurasthenic type lest symptoms referable to them be conjured up and perpetuated. Many authorities hold the view that the dropped position of the viscera is not the cause of the symptoms but that it is merely an incident in the general condition. Even so the radiographic appearances give an indication of its existence and by excluding the presence of any more serious organic lesion help in arriving at the correct diagnosis.

Radiological Features — There are certain landmarks in this respect which are of help in differentiating between the normal hyposthenic position and true ptosis.

STOMACH — This organ if hypotonic may simulate ptosis from the sagging of the greater curve. The position of its lower pole varies greatly in different individuals and also from day to day in the same subject. This variation is due to varying tone and has nothing to do with the peritoneal attachments of the stomach. In true gastrophtosis the descent is due to stretching or increasing laxity of the gastro hepatic omentum and is indicated by the position of the lesser curve and pylorus. If the *incisura angularis* is below the intercrestal line in the erect posture the stomach may be said to be ptosed.

THE DUODENUM other than the bulb may take no part in this dropping in which case the bulb is frequently narrow and elongated. More commonly the whole loop together with the head of the pancreas is prolapsed.

THE SMALL INTESTINE is normally so variable in position that it presents no satisfactory criterion of ptosis.

THE COLON is more frequently displaced downwards than any other viscera. The transverse colon is so often in the form of a dependent loop that no significance attaches to it. The position of the splenic flexure is much the safest criterion of coloptosis. Normally this is fairly constant in site in the left diaphragmatic cupola and its descent towards the iliac crest is always an index of ptosis. The right half of the colon is so variable in position that only gross displacement downwards is of importance. Another characteristic feature of coloptosis is the tendency of the colon to become slightly crowded towards the midline like a concertina. The transverse colon assumes an undulating shape and the flexures are not so far apart as in the normal.

THE CECUM may show a marked mobility and considerable variation in position in the erect and supine postures. This variation or shift on change from the erect to the supine posture is much greater than in the normal. *Kantor* regards a shift of more than 3 inches on the right side as an indication of what he calls hypofixation. An antero posterior radiogram taken with the patient lying on his left side (the central ray being horizontal) will demonstrate the caecal mobility in the form of a displacement towards the midline. This is however rarely necessary. Radioscopic palpation in the supine position is nearly always sufficient to demonstrate the degree of lateral caecal mobility.

THE LIVER when it descends in visceroptosis tends to rotate forwards and casts a larger shadow from above downwards. This has its clinical counterpart in increase of the liver dullness downwards and is liable to be mistaken for enlargement of the organ.

THE SPLEEN does not cast a very defined shadow but sufficient can usually be made out to detect any marked ptosis of it.

ANOMALIES OF SIZE

Congenital Dilatation of the Colon (*syn* Megacolon Hirschsprung's disease)—This condition is characterised by a varying degree of dilatation and hypertrophy of the colon without any causal organic obstruction and obstinate constipation dating from birth. The more severe cases are met with in young children lesser degrees of dilatation often survive to adult life.

MORBID ANATOMY—The dilatation may involve the whole or part of the colon. When only part is involved the dilatation extends for a varying distance up the colon. The cecum is the portion which most commonly escapes. The rectum is not involved nor is the small intestine.

In addition to the dilatation the colon is elongated. This is apparent particularly in the sigmoid the segment most constantly affected. *Mega sigmoid* when marked results in the sigmoid loop extending far up into the abdomen not uncommonly into the left hypochondrium. The bowel wall also shows muscular hypertrophy and in long standing cases fibrous hyperplasia. The obstinate stasis that occurs in this condition may lead to stercoral ulceration.

ETIOLOGY—The pathogenesis of the condition was quite obscure until *Hurst* pointed out its similarity to oesophagectasia in cardiospasm and included it in the list of disorders resulting from derangement of the sympathetic neuromuscular mechanism. The writer recently saw a case in a boy of 6 associated with gross double hydronephrosis, hydro-ureter and vesical dilatation. Further proof of the truth of *Hurst's* theory is given by the successful results—sometimes dramatic—of abdominal sympathectomy in these cases an operation which has greatly improved the prognosis of Hirschsprung's disease.

CLINICAL FEATURES—The more marked cases are usually recognised during the first year of life. These frequently succumb at an early age from toxæmia or perforation. The milder degrees may escape recognition till later childhood or early adult life. The usual symptom is obstinate constipation dating from birth, and gradually increasing abdominal distension. Tympanites is very common and if ulceration has occurred diarrhoea may alternate with the constipation. Seybala nearly always form in the dilated gut and it is usually very difficult to empty the colon completely either by purgatives or enemas. The child shows general signs of chronic toxæmia and the general nutrition is defective contrasting with the large abdomen.

RADIOLOGICAL FEATURES—Because of the gaseous distension of the colon that is usually present a plain radiogram often demonstrates the dilated coils clearly but does not show enough detail to differentiate a moderate degree of Hirschsprung's disease from obstructive colonic dilatation.

The barium meal should never be used in the investigation of these cases because of the difficulty of getting rid of the impounded barium. If it is used an obstinate stasis is evident together with marked colonic dilatation. The

barium occupies only a portion of the lumen in any segment surrounded by considerable collections of gas.

The barium enema is the method of choice. In the milder degrees of congenital dilatation it is possible and not injurious to fill the whole colon and in those cases where the dilatation although gross is limited to the lower part of the colon it is also permissible. In marked cases involving the whole of the large gut it is neither possible nor desirable. The capacity of the colon may then be anything from 5 to 10 pints or more. It is the writer's practice not to introduce more than 4 pints and to rely on gaseous contents to outline the upper portion. Changes of posture e.g. prone and right lateral may aid in filling the upper colon.

The appearances are typical in a marked case. The enema fills the rectum out to its normal size and when the sigmoid is outlined it is seen to be approximately equal in calibre to the rectum. Hastrations are either absent or very slight. The sigmoid loop may be very long and in the form of an acute Ω with the bend in the upper abdomen. After the sigmoid has been filled some of the barium passes into the colon above but usually gaseous contents therein prevent complete filling. It is rare for the barium to reach farther than the splenic flexure in these advanced cases.

In the less marked cases the whole colon can usually be shown by a barium enema and in addition to the dilatation the hastrations are wide and rather shallow (Fig. 184).

Two forms of volvulus are apt to take place in megacolon—(a) volvulus of the sigmoid and (b) secondary volvulus of the stomach either along its long or its transverse axis. Both are described elsewhere.

RADIOGRAPHIC APPEARANCES AFTER SYMPATHECTOMY—Three operations are at present in vogue: (1) removal of the 2nd, 3rd and 4th lumbar sympathetic ganglia on both sides with the connecting rami; (2) resection of the medially directed branches of these ganglia only (Telford and Stopford) and (3) periarterial sympathectomy by stripping off the plexus surrounding the first inch of the inferior mesenteric artery. In the latter operation the ascending branch from the sacral autonomic plexus which joins the arterial plexus must not be cut. If it is the operation will fail to improve the condition.

Of these operations the last is if anything more in favour at the time of writing but satisfactory results are obtained by all and also failures.

The radiographic appearances after operation are variable. In some successful cases there is a marked diminution in the colonic calibre (Fig. 184).

In others there is no appreciable diminution when filled by a barium enema in spite of an excellent physiological result. Persistence of the dilatation after operation therefore does not indicate that the operation has been unsuccessful. In these a barium meal gives a truer picture of the real state of affairs.

Other operations which are performed on occasion are colectomy, complete or partial, and ileo sigmoidostomy (Fig. 185)

Cœliac Disease (syn. Gee's disease, Herter's disease, idiopathic steatorrhœa)

This is a chronic disorder of nutrition, characterised by wasting, abdominal distension and frequent pale stools. The essential feature is an

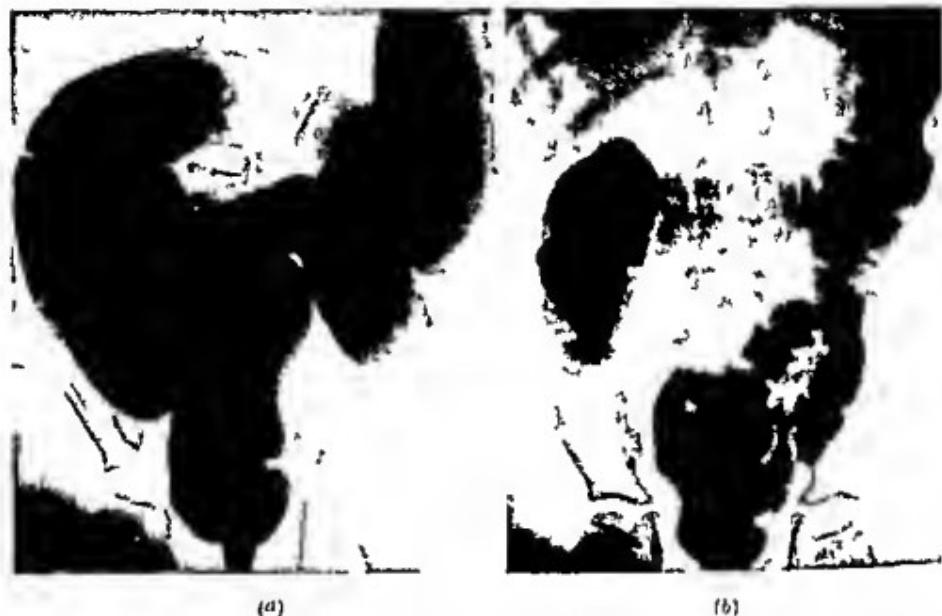


FIG. 184 Hirschsprung's disease. (a) before operation. (b) 18 mos. after a successful lumbar sympathectomy showing marked diminution in the calibre of the colon.

intolerance of fats and carbohydrates in the diet. The cause is uncertain. The intestinal mucosa may be atrophic and the small and large intestines (particularly the latter) diluted. The condition is usually met with in children between 1 and 5 years of age. It also occurs in adults.

Radiological Features

INFANTS—*R. Gilbert* and *L. Babany* have investigated the radiological appearances in infants and have described changes both in the motility of the small intestine and in the calibre of the colon. The transit of a meal through the small intestine may be unduly rapid in early cases but in the later stages it is usually delayed. These writers also noted an irregularity in the rate both in the small and large intestines. At one time jejunal and ileal transit may be

rapid and at another stasis may occur. Similarly the colonic activity may vary between stasis and frequent but tiny evacuations.

Both the large and small intestines are usually dilated particularly the latter. This may be demonstrated by a barium meal and in the case of the colon by a barium enema. There is a tendency to irregular flecking of the small intestine the barium being distributed in separate distended coils with gaps between. The colonic shadow when seen by a barium meal may be mottled from mixture of translucent and opaque contents.

ADULTS—According to *J. M. Snell* and *J. D. Camp* the small intestine shows definite radiological changes when investigated by a barium meal. In three cases which they report transit through the jejunum was delayed and the normal feathered markings in the gut were absent. In place of the latter the barium was disposed in aggregated elongated masses along the jejunum. These writers attribute this appearance to the presence of inflammatory changes in the mucosa and submucosa and to the abolition of the normal activity of the muscularis mucosae.

T. J. Od. Bennett, *D. Hunter* and *J. M. Vaughan* have described fifteen cases in adolescents and adults. The clinical features in the cases were fatty stools with or without diarrhea, tetany, anaemia, skin lesions, infantilism, osteomalacia and colonic dilatation. In eight cases examined with a barium enema six showed colonic dilatation varying from a moderate enlargement of the descending portion to an extreme megacolon.



FIG. 165.—Colectomy and ileo-sigmoidostomy for Hirschsprung's disease. Faecal appearance 7 hours after a barium meal. Note the flattened stool.

Th E Hess Thayson found colonic dilatation in four out of five adult cases examined and noted that this dilatation began in the sigmoid and gradually extended upwards.

Franconi has stated that if the colon is thoroughly emptied by lavage it temporarily assumes a normal calibre.

There remain to be described some of the rarer gross congenital defects which are often incompatible with life. Amongst these are absence of entire colon or part thereof, double-barrelled colon, and micro colon.

Absence of Colon—The entire colon rectum and anus may fail to develop but more commonly only a portion is involved. The cecum may be absent and the ileum pass directly into the ascending colon without the usual splencter or the right colon may be absent and the ileum be joined to the transverse colon.

If a large part of the colon is absent an umbilical faecal fistula may be present—via a patent Meckel's diverticulum.

Double-barrelled Colon—This is extremely rare. *Lockwood* has reported a case of a descending colon with a double lumen each patent at both ends. One lumen the larger performed the colonic function.

Micro colon—This too is a rare congenital abnormality which is usually incompatible with life. It may be partial or total. *Fyfe* and *Lardennois* have each reported a case of total congenital micro colon the lumen being narrowed to a few millimetres.

D M Greig has made an exhaustive study of four cases and points out that the colon may also be ectopic (e.g. the cecum near the site of the normal splenic flexure) and also that the lower ileum may be considerably dilated.

F B Stephenson also records two cases. Both showed incomplete rotation of the colon. In one the cecum was subhepatic, in the other sub-splenic. In the latter the ileum was grossly dilated and the colonic lumen was 5 mm in diameter. The rectum was also indistensible. Both cases died shortly after birth.

ANOMALIES DUE TO ADHESIONS AND HERNIAE

Peritoneal Adhesions involving the Colon

Peritoneal adhesions between adjacent coils of intestine and between them and the parietes are very common much more so than would appear from X-ray examination.

The great majority of adhesions are symptomless and give no radiographic sign of their existence. A small percentage give rise to symptoms but are undemonstrable and a still smaller percentage cause symptoms and can also be shown radiologically.

The X-ray demonstration of adhesions of the colon depends on three effects of the adhesion—fixation of the adherent viscera, deformity of its contours,

and obstruction to the onward passage of its contents. At the same time the mucous pattern of the colon should remain intact (Figs. 186-187).

Fixation of the colon by adhesions can be demonstrated only if the viscera is normally mobile and if it is accessible to radioscopic manipulation. The cecum fulfills both these conditions and fixation of this viscera is a reasonably strong indication of pericecal adhesions. This constitutes one of the accessory signs of appendicular disease. The ascending colon, hepatic flexure and proximal two thirds of the transverse colon are similarly accessible to the palpating hands and are usually mobile but the hepatic flexure may have no mesocolon



FIG. 186.—A case of *two lobes in one patient* aged 6. Thought at first to be a carcinoma, then ptyalase of the sigmoid enema showed a normal mucous pattern and ended a simple lesion. At operation of course a fibrosis were found.

and so have little mobility while hypertonic abdominal muscles may prevent free manipulation of the transverse colon. The splenic flexure is far out of reach of the palpating hand unless it is passed and adhesions in this region e.g. from perisplenitis cannot be detected radiologically unless they cause obstruction. The descending and iliac portions can again be palpated satisfactorily but the pelvic loop is frequently placed too deeply in the pelvic basin for this purpose.

The deformation of contour most typical of a lesion is an abrupt angulation. This angulation must be a real one—that is it must be distinguished from a rounded bend in the gut viewed end-on. Such an angulation is usually

accompanied by some narrowing or compression of the colonic lumen, which if marked, produces the third sign, *obstruction of the lumen*. It should be noted that an adhesive obstruction of necessity shows fixation also, and probably deformity or angulation. It is extremely unlikely that an obstructed colon which is mobile at the point of obstruction is due to an adhesion band.

Adhesions is a diagnosis to be shunned except on clear evidence. It is a non-committal diagnosis one that nowadays seldom leads to operative



FIG. 187.—A case of a illosions from calculous cholelithiasis. (a) Filling defect in the descending colon with a barium enema simulating a carcinoma. (b) After air inflation mucous plug showing in the stenosed segment.

interference except in very definite obstructive cases, and one that comes too easily to the pen of those expected to solve the mystery of the patient's symptoms by X-ray examination. It is still a regrettably common diagnosis on slender evidence and more commonly wrong than right.

Herniation of the Colon—The splenic flexure is not uncommonly present in a left diaphragmatic hernia and always in Petit's elevation. The transverse colon may occupy a ventral or umbilical hernia and the cæcum and/or sigmoid be present in the inguinal and femoral varieties.

CHAPTER XXI

INFLAMMATORY DISEASES OF THE COLON

SIMPLE COLITIS

COLITIS is a term applied to many varied conditions, from the so called irritable spastic colon to the graver forms of ulcerative colitis. Obviously the radiological picture must vary according to the type that is present. The radiological separation of the various types has been assisted by the adoption of the thorium three stage enema.

Irritable Colon : Colospasm

The simplest type is the reflex neuro muscular and vascular disturbance described by *Maingot* as the *état irritatif* and commonly termed in this country colospasm or the "irritable" colon. The adjective "irritable," thus loosely used, is meant to indicate a state of affairs in which the colon tends to a state of muscular hypertonus and hyperactivity of the *muscularis mucosæ*. It is said to result from many intrinsic and extrinsic abdominal lesions, and also from numerous remote constitutional disturbances. *Maingot* has compiled a formidable list of causative factors. Amongst the general factors he groups nervous, endocrine, and allergic disturbances, leukaemia, drugs, such as pilocarpine and purges, and general toxic states.

Amongst abdominal emissive factors, he includes almost any lesion that can occur in the abdomen.

RADIOGRAPHIC FLATENES—*The barium enema shows a relatively hypertonic small bored colon with fine haustral contractions.* This is particularly so in the left half of the colon, and in those cases which are so commonly labelled colospasm on radiographic examination the enema may be completely arrested by a temporary spasm of quite a long segment of the *ileum* or descending portion of the colon. After a little this usually relaxes enough to allow the upward passage of the medium.

The thorium triple method gives characteristic signs by which this colitic syndrome or reaction may be recognised. The mucosal pattern after emptying shows the plicae to be smaller and more numerous. In addition to the normal transverse plicae there are added secondary arborisations which make a close-set and complicated pattern.

This change is supposed to be the result of stimulation and increased activity of the *muco-vascular* mucosæ. *Pari passu* with this some increased vascularity may be present. This causes thickening of the plicae, and represents the so called *état exudatif*.

Most commonly a mixed reaction takes place and with the secretion of excess of mucus the picture is that of simple mucous colitis.

Mucous Colitis

The radiographic features of mucous colitis are slight and inconstant or absent altogether in a barium meal or enema examination but with a thorium air or barium air enema more definite changes may be detected.

With the barium meal constipation and formation of seybals are common concomitants but they are not essential parts of the radiological syndrome rather are they commonly associated states. A not infrequent appearance is

the change known as *Crane's* string sign. This is a streak or snail track of barium laid down in the lumen of the empty colon in the trail of a mass movement. It is a variable and unreliable sign since it may be present not only in this condition but also in developed ulcerative colitis and in the normal subject. It may extend over a foot or more of the colon and is most commonly seen in the descending portion.

With the barium enema usually no changes are apparent unless there be some hypertonicity of the muscular coats again especially on the left side and some fine haemorrhage. In some cases adherent mucus causes fine irregularities in the barium filled contour of the gut. These disappear after thorough preparation a point which distinguishes the condition from ulcerative colitis in which the irregularities are persistent.

The thorium-air enema shows a similar appearance in the first stage that of

Fig. 188.—Thorium air enema at an early stage showing the increase in complexity of the mucous pattern in a case of mucous colitis.

filling. The collapsed lumen typically shows increase in number and thickening of the plicae with a tendency to formation of opaque blobs at points (Fig. 188). After distension with air these thorium coated drops of mucus can be seen adhering to the mucosa *en face* and in profile. A similar appearance may be with the barium air enema after inflation.

ULCERATIVE COLITIS

Etiology—Ulcerative colitis may result from a variety of causes such as

(1) SPECIFIC INFECTIONS among the principal of which are amebic and

bacillary dysentery the typhoid-paratyphoid group lamblia tuberculosis and syphilis

- (2) CONSTITUTIONAL secondary to Bright's disease gout or plumbism
- (3) STERCORAL ULCERATION especially above a stricture
- (4) VASCULAR following vascular disturbances such as portal obstruction or mesenteric embolus

(5) PARAPLEGIC

With the exception of the tuberculous and syphilitic groups the specific forms of ulcerative colitis tend to become secondarily infected and to merge into the non-specific type.

The bacteriology of the non-specific type is obscure. The most serious and acute cases are said to be the result of streptococcal or pneumococcal infection but usually a variety of organisms is present.

Pathology — Three stages may be recognised in the condition: the stage of onset, the developed stage and the stage of advanced fibrosis. The three stages show different pathological features depending on the pathological changes.

In the first stage the mucosa is swollen and congested and the submucosa shows lymphocytic infiltration. Miliary submucosal abscesses develop. When these break down tiny ulcers form and as these increase in size the second stage is reached. The submucosal coat becomes thickened and ulcerous and the lymphocytic infiltration increases leading to minute haemorrhages. The ulcer margins may become undermined and if an abscess develops between the muscular coats a collar stud cavity or false diverticulum may occur. The ulcers tend to develop in the haustral excrescences. In widespread confluent ulceration the remains of the mucosa



FIG. 189.—Third stage of ulceration in a case of recto-colitis.

(a)

(b)



(c)

(d)

FIG. 190.—A case of ulcerative sigmoiditis proved by sigmoidoscopy.

(a) Barium enema reveals no abnormality. (b), (c) and (d) show the characteristic signs by a thorium three-stage enema—the woolly outline in the first stage, the absence of a mucosal pattern in the second, and the irregular contour line in the third.



FIG. 192.—Gross ulcerative colitis, with polyoidal formation and structure 4. Seven hours after an opaque meal.



FIG. 191.—Ulcerative colitis, steroid stage, with "shaggy" contour, from multiple deep ulcers and mucosal edema. The "double contour" effect is visible.

produce a naked-eye appearance like a honeycomb. An important feature of this stage, from the radiological point of view, is the relative loss of elasticity of the bowel wall, the result of infiltration of the submucosa and muscularis. *Restitutio ad integrum* can take place only if cure is achieved in the early stages. In later stages healing takes place, if at all, with fibrosis. In chronic late cases there is often a mixture of mucosal granulomatous nodular or polyposid formation, with submucous and muscular fibrosis and scarring. Both of these are radiologically important.

Sooner or later in advanced cases, cicatrical contracture causes localised stricture or general contracture of the bowel and if a colostomy has been performed the colonic lumen may become completely obliterated. This last occurrence is demonstrated by the failure to introduce a thin barium cream or thorium suspension along the colon by either the stoma or the rectum.

Radiographic Features

STAGE OF ONSET—The ulceration usually begins in the sigmoid and it is there that the first changes are visible.

When filled with a barium enema the affected segment may show some hypertonicity and its contour may be rather shaggy.

The same appearance is seen in the first stage of a thorium enema. The mucosal pattern in the second stage, that of collapse, is characteristic. The plication of the mucosa is completely disordered. There is no symmetry in the pliæ which take the form of an irregular enlarged and mottled network. Gas inflation proves the colonic wall to be normally distensible. The opaque contour line is interrupted and irregular and tiny ulcer crater may be detectable on occasion. The mucosal surface seen en face may present irregular opaque droplets of the opaque medium.

DEVILOID STAGE—As the process develops the radiological picture changes. The ulcers are larger and tend to be confluent their margins undermined and the affected portion of the wall infiltrated and thickened.

The barium enema method begins to reveal characteristic signs. On observing thoroscopically the enema running in the impression is gained of a rigid contracted tube. Haustration is feeble or absent and the transit of the enema through the colon very rapid. The absence of haustration produces the well known ribbon sign (Fig. 193). The colon appears as a smooth ribbon shadow often if cicatrices have not developed remarkably uniform. This appearance is due to the rigidity resulting from the infiltration of the submucous and muscular coats. An ulcer crater seen in profile causes an irregularity on this smooth outline if its edges are undermined notches may be seen. The undermined mucosa may result in a double contour in small sections of the colonic profile.

With the thorium enema the stage of filling shows an appearance of the same type as above but the lesser degree of filling allows more irregularity of

the contour to appear to which undermined craters, hypertonicity, infiltration, and fibrosis may all contribute. False diverticula may be present and be visible. The stage of collapse is marked by a failure to collapse completely. The bowel wall has lost its elasticity and the lumen is not emptied sufficiently to develop a satisfactory mucous pattern. In those segments which do empty themselves the plicae are scanty and ill developed. The stage of inflation proves that the rigidity of the colonic wall is relative—the lumen is larger than in the first stage. The contour here is very irregular and broken by spiky projections and, maybe false diverticula. The intermarginal zone shows coarse irregular reticulum.

HYPERTROPHIC AND SCIRROTIC STAGE—The barium enema shows very typical changes. The rigid tube and ribbon shadows persist and there is a considerable diminution of the colonic lumen. Irregular stenosed segments are clearly visible and haustration is completely absent. If in addition to the hyperplastic fibrosis the mucosa develops polypoid granulomatous changes these will add a further irregularity to the contour.

The filled stage of the thorium enema shows a similar appearance. Collapse of the colon barely takes place and no mucosal plicae can be visualised. Inflation causes slight dilatation of the less affected portions of the gut but is unable to distend the stenosed sclerosed portions. The mucosal pattern *en face* is a disorganized reticulum in which ulcer crater or diverticulum may make itself visible.



FIG. 493.—Developed ulcerative colitis with absence of haustra and ribbon contour.

COLITIS DUE TO SPECIFIC INFECTIONS

Those forms of ulcerative colitis resulting from infection with the ent amoeba histolytica, lamblia trichomonas or the dysenteric bacillus show no radiological features to distinguish them one from another or from the non-specific forms described above.

The diagnosis rests securely on the results of bacteriological examination and this established radiographic examination serves to indicate the degree of the pathological changes. The earliest stages show the appearances of a mucous colitis, the later those of an ulcerative colitis in its various stages.

down to the contracted fibrotic stage. It is said that if the amoebic form becomes chronic it shows in its late stages an especial tendency to fibrotic contracture of the gut.

SYPHILITIC COLITIS

This condition is extremely rare and exhibits a preference for the sigmoid and rectum.

The essential lesions are granulomatous formations and ulceration. In general specific sigmoiditis may take one of two types—an infiltrated variety



FIG. 134 Polypoid ulcerative colitis showing 'honeymoon' pattern four hours after a meal.

in which the submucosa is permeated and the sigmoid transformed into a rigid tube and a hypertrophic variety in which the wall of the gut is greatly thickened and nodular and the lumen irregularly narrowed. The deciding diagnostic points are however not radiological but serological histological and therapeutic.

ILEO-CÆCAL TUBERCULOSIS

Pathology—Hyperplastic tuberculosis of the bowel affects the cæcum in the majority of cases and may spread thence to the ascending colon and the last inch or two of the ileum. The feature of the condition is the marked thickening of the cæcal wall and consequent narrowing of its lumen.

The disease starts in the submucous coat with a diffuse round celled infiltration, followed by a considerable fibrous hyperplasia, both in and round the wall. The mesocolon may be involved and, by contraction, drag the cecum upwards. The ileo cecal and adjacent mesenteric glands are often affected. Eventually the lumen of the bowel becomes fibrosed and markedly narrowed, with gradually increasing obstruction.

In addition to the hyperplasia, ulceration of the mucosa may take place, and polypoid vegetations may grow into the lumen.

Clinical Features—The disease is most commonly met with in patients between 20 and 40 years of age, and has an insidious onset. There may or may not be a preceding involvement of the lungs. In the early stages the patient may complain of little more than vague ill health, and a sense of discomfort in the right iliac fossa. With the onset of ulceration, diarrhoea and the passage of blood and mucus may occur. As the disease progresses further, a palpable mass becomes detectable in the right iliac fossa, and signs of chronic ileal obstruction make their appearance.

Radiographic Features—These depend on the stage of the disease. In the early stages, before the onset of obstruction, the abnormal appearances result from the rigidity and contraction of the cecal walls. Stierlin has described a sign which he believed to be pathognomonic of caecal tuberculosis. This consists of a gap in the barium shadow in the cecum when the ileum, caecum, and proximal colon are filled by a barium meal. At, say, six hours after the ingestion of the meal, the ileum is filled down to the ileo cecal valve, and also the ascending colon, the cecum, on the other hand, remaining empty. Although in some cases this is a pure spastic phenomenon, it is sometimes due to spasm and organic contracture combined. The amount of deformity due to each factor can be determined by a barium enema, a method which delineates the degree and contour of the narrowed lumen with much greater certainty, and which should be used in every case that shows a suspicious appearance with the barium meal. The type of filling defect with a barium enema depends on the macroscopic form of the disease present. When hyperplasia predominates, the narrowing is more regular, and is of the kind seen in scirrhouss carcinoma of the stomach. When filled with the barium enema, the cecum is frequently conical the apex downwards. The margins of this cone may be fairly smooth or jagged and indented. The presence of nodular masses projecting into the lumen causes irregular "finger print" defects in addition to the hyperplastic narrowing. When the ileum is involved the barium meal may show an irregularly narrowed portion contrasting with the normally filled portion proximal to it. Stierlin's sign is not exclusive to ileo cecal tuberculosis. Fig. 162 shows a classical Stierlin's sign in a case of Crohn's disease.

With the onset of chronic obstruction, the radiographic picture of ileal stasis is added to the picture. This is shown only by the meal which should

therefore be used as a routine in addition to the enema in the investigation of these cases.

The mucous pattern shown by the thorium flocculent enema may show features of importance in the diagnosis. These vary according to the predominant pathological process in the case.

In the ulcer hyperplastic form the affected cecum shows in the collapsed stage of the thorium enema absence of the pheæ which have been destroyed by the disease or a few scattered and disorganized pheæ separated by areas



(a)

(b)

FIG. 10. Tuberculosis of the cecum and ascending colon.
(a) Seven hours after an opaque meal. Show no obstructive ileal stasis and Stern's sign.
(b) The same at 1½ hr by a barium enema.

with no sign of pheæ. Inflation of the colon fails to distend the cecum to an extent depending on the degree of infiltration and rigidity of the wall of the gut. Hyperplastic nodules may be seen in relief but as a rule the distension is insufficient to show them. The colon distant from the actual lesion may show a reflex irritated state of the mucosa as described under the section on colitis viz. increase in number and decrease in size of the pheæ, their general arrangement remaining intact. The ascending colon adjoining the affected cecum may show a mixture of these states—areas of involvement by the specific process with adjacent areas of normal but reflexly irritated mucosa.

In those cases in which the hyperplasia becomes polypoid the latter state

adds a typical feature to the local mucosal picture—an irregular opaque network outlining rounded clear areas of varying sizes and shapes—the polypoid masses.

In the fibrotic form the conical constriction is more marked when filled with the enema. In the stage of collapse no place are visible but the colon elsewhere is said not to show reactive changes. Dilatation by air is impossible because of the rigid fibrosed cæcal wall.

Differential Diagnosis—It is obvious from the above that cæcal tuberculosis presents a radiographic picture very similar to carcinoma so much so that they



FIG. 196.—Multiple tuberculous stenoses in the colon.

are as a rule radiologically indistinguishable. Calcified neo-cæcal glands may be visible and suggest tubercle as the cause but with no certainty since they may represent merely a juvenile adenitis long since healed and may have no connection with the active cæcal lesion. If the barium meal shows involvement of the ileum also a tuberculous lesion is indicated.

Localised appendicitis abscess or *fibrotic sequelæ* from an old abscess may also cause so similar an appearance as to be indistinguishable in a barium enema but the thorium method shows a normal mucosa which serves to differentiate.

them. Unfortunately the thorium enema is often unsuccessful so far as the caecum is concerned.

As a general rule no confident radiological differentiation can be made between ileo caecal tuberculosis and carcinoma, and the safe rule is to regard the condition as the more serious, unless clinical, serological and bacteriological evidence gives a lead. Even if the condition is mistaken for carcinoma no great harm is done, since the tuberculous lesion is likely to come eventually to surgical interference.

Actinomycosis of the ileo caecal region is similarly indistinguishable radiologically.

ACTINOMYCOSIS OF THE COLON

This is a rare disease, and its radiographic appearances are as a rule indistinguishable from cancer.

Querneau describes a case involving the descending colon, showing with a barium meal a constriction of the gut similar to that of a scirrhous carcinoma. The absence of ulceration of the mucosa was noteworthy in this case.

L P Good reports a series of sixty two cases of abdominal actinomycosis, and points out that the primary lesion in 77 per cent of them was the ileo caecal lesion. The majority start with the signs of acute appendicitis, and after appendicectomy a sinus persists and a thickened mass develops in the right iliac fossa from the brawny leathery infiltration of the surrounding tissues. The ileum and caecum are commonly involved in this infiltration. Ileal stasis is prone to result and the contracted, deformed, fixed caecum may be seen in a barium enema. The filling defect is often indistinguishable from carcinoma or tubercle and the diagnosis is ecological. As the disease progresses abcesses tend to develop in the lungs, liver, kidneys and abdominal wall.

CHAPTER XVII

COLONIC STASIS AND OBSTRUCTION

CONSTIPATION

CONSTIPATION or functional stasis in the large intestine is difficult to define on account of the marked variations which occur in normal individuals. In some subjects the normal habit is two or three evacuations per diem, in the great majority one per day, but on the other hand one evacuation every two or three days may be consistent with normal health.

Constipation is one of the commonest complaints of neurotic individuals and is often complained of even when it does not exist. It is a commonplace that in such patients who regularly dose themselves with aperients and purgatives of all kinds the failure to obtain an evacuation on a single day at once precipitates an array of symptoms such as abdominal discomfort and distension, actual pain, nausea, lassitude, dizziness, etc. In many of these cases it is obvious that the symptoms are part of the neurosis and that they are produced not by the constipation but by the knowledge that the bowels have not acted. Radiology may be of help in the management of these patients by demonstrating that there is no real stasis in the colon, that it is controlled adequately by simple laxatives or that the stasis is rectal in site and therefore without serious constitutional effects.

The chief value of radiology in the investigation of constipation is in differentiating functional stasis from the organic obstructive type. This is discussed in the section on organic obstruction of the colon. Three types of functional constipation are described according to the site of the delay—caecal, colic and rectal.

Cæcal Stasis—This is rare and is detected only by a barium meal examination. The patient is unaware of the condition since daily evacuation takes place in the normal way and it is doubtful if it has any clinical significance. The main length of the colon empties itself in normal time but the cæcum tends to retain barium. Some writers have described it as one of the signs of chronic appendicitis but this relationship is also very doubtful. *Barclay* suggests that it results from a defect in the mechanism of the mass movement of the colon. He puts forward the view that if the *point d'appui* of this peristaltic wave (in other words the initial constricting ring) is incomplete some of the colonic contents are forced backwards into the cæcum and pack it. This appears to be the most reasonable explanation.

Colic Constipation—This is the commonest type of constipation and results from a failure of the normal mass movement. In some cases the

supposed delay is physiological and represents the normal colonic habit. In others it is pathological and may be associated with various conditions such as the neuroses, visceropatosis and mucous colitis. Poisons such as lead acetate and the opium group tend to abolish the reflex and so produce stasis. Absence of residue in the diet is said to be a factor but if so it is not an important one in most cases.

RADIOGRAPHIC FEATURES.—The stasis may take place anywhere in the colon proper and is most common in the transverse portion. It is demonstrated clearly by a barium meal but in some cases the stasis as shown by the barium meal is less than with ordinary food. The mass of the barium in the colon may exert a mass movement in a way that the normal contents do not do. The experiments of Alvarez and Freedlander with glass beads with and without a barium meal confirm this slight accelerating effect of barium sulphate. In the early stages of the barium meal examination the contrast medium may be disposed evenly in the transverse colon with deep regular haustrations but on succeeding days scybala are formed and the barium tends to be scattered in irregular masses especially in the distal portions. This irregular distribution with intervening portions of empty gut and the absence of any colonic distension are important indications of the functional nature of the stasis. In mild degrees of stasis most of the barium is evacuated in three days. In severe degrees a week or more may elapse but it may be too uncomfortable for the patient to prolong the examination to the end in these cases. A shorter examination gives the necessary information and the efficiency of the patient's usual appliance may then be usefully determined.

Rectal Constipation (*syn. dyschesia or dyskezia*).—This is a common variety and results from the loss of the defecation reflex. The commonest cause of this loss is neglect. The patient gets into the habit it may be in childhood of ignoring the daily call to stool and the reflex gradually disappears. In addition to or in place of simple neglect there may be other causes. Weakened abdominal and pelvic muscles from repeated pregnancies tend to make defecation more difficult and act as contributory causes. Inflamed piles, fissure in ano and chronic inflammation of the anal canal make defecation painful and tend to inhibit the reflex.

RADIOGRAPHIC FEATURES.—The characteristic appearance with a barium meal is the collection day by day of an increasing mass of barium in the rectum until in a marked case the latter is dilated out to the size and shape seen in a normal barium enema examination. If a moderate mass is seen on screen examination at the twenty-fourth hour and the patient admits to no desire to go to stool the presence of dyskezia is probable. A larger mass present on the following day confirms it.

While constipation can be radiologically examined only by the barium meal it is so important not to overlook any organic colonic cause of the stasis that the meal should be followed by a barium enema in every case in which there is the least doubt.

COLONIC OBSTRUCTION

Acute Obstruction of the Colon is too urgent a condition to allow of any lengthy radiological investigation such as a barium enema. Its presence and site can however be shown in many cases by a plain radiogram of the abdomen. This is a feasible procedure in an institution where a mobile ward equipment is available. The colon above the point of obstruction tends to become distended with gas and so is visible. In favourable cases this distension extends right down to the obstruction and locates the latter. This does not always obtain and care must be exercised in naming the exact site. Frequently the evidence has a negative rather than a positive value. Thus if the cecum and transverse colon are uniformly distended it can be said that the obstruction is not above the splenic flexure and a statement even as indefinite as this may give the surgeon the indication he requires in planning his incision. The presence of fluid levels in the bowel above the obstruction is often an important diagnostic feature. These may be shown in a lateral view taken with the patient supine.

Chronic Obstruction of the Colon
—Radiology as a rule gives definite evidence regarding the presence of this apart from the actual demonstration of the causative lesion. The barium meal and enema both give a characteristic picture in a well marked case.

THE BARIUM ENEMA should be used first but prior to that a plain radiogram may give some preliminary indication if much gas is present. The presence of fluid levels should be noted.

With the barium enema the lower the obstruction the more definite are the signs. The demonstration of obstruction by this method depends on the arrest of the barium column at the obstruction and owing to the difficulty of ensuring a pressure of any moment in the cecum and ascending colon a halt in flow of the enema at that point is of less significance than in the descending or sigmoid regions. In a well marked chronic obstruction in the latter



FIG. 19.—A plain film of the lower abdomen showing obstruction to a barium enema.

regions, the sequence of events with a barium enema is as follows. The rectum fills out normally, and the barium passes in the usual way up to the point of obstruction. Continued administration of the enema then causes gradual distension of the already filled gut, without any advance of the head of the barium. A little of the enema may be forced through the obstruction the amount depending on the severity of the latter. At the same time the patient experiences a gradually increasing distress and desire to evacuate. This

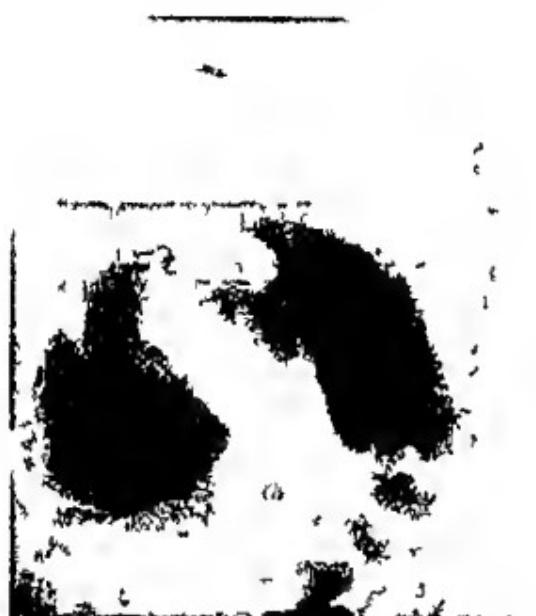
culminates if the administration is continued in the escape of the enema past the rectal tube.

When these four features are present—arrest of the head of the enema increasing distension below increasing distress and finally escape of the enema—a diagnosis of obstruction is justifiable and is usually correct even if the actual obstructing lesion is not demonstrated. The lower the obstruction the more diagnostic are these signs. Fortunately in most cases the actual lesion is seen such as the filling-defect of a carcinoma, the jagged contraction and barium filled pockets of diverticulitis or the sickle shaped defect of extrinsic pressure and these clinch the diagnosis.

FIG. 118. Obstructive annular carcinoma of the left half of the transverse colon shown by a barium meal. The actual site of the growth is visible and proximal to the stricture the colon is distended and shows a fluid level.

It is often found in investigating those cases due to carcinoma that the obstruction to the enema is greater than to a barium meal. Kerley points out that the constriction tends to be funnel-shaped, with the narrow end below. There may therefore be a tendency to valve action in a direction retrograde to the normal flow.

The BARIUM MEAL affords evidence as to the degree of stasis above the constriction and the degree of dilatation. It is safe to use it when the obstruction is high e.g. the cecum since inspissation of the barium will not occur in that region. In obstruction low down care must be taken not to carry the examination over too long a period.



The appearances with a barium meal vary according to the site. In cæcal obstruction the stasis is in the ileum—it has been described in that section. When the obstruction is lower down, the first changes are in the colon. On following the barium in its progress along the colon, several changes are observed. The cæcum and ascending colon fill to a wide extent, but the onward progress is slow. The transverse colon, when reached, is seen to be considerably dilated, and the haustral contractions large, wide, and few in number. As the region of the obstruction is approached the head of the barium column loses its homogeneity, because of its admixture with the transparent colonic contents in front of it. This last feature is very characteristic.



FIG. 129.—Obstructing carcinoma of the descending colon with marked gaseous distension of the colon above (Barium enema supine.)

of obstruction, and is rarely, if ever seen in functional colonic stasis. In organic obstruction the proximal colon gives the appearance of being "packed" with barium. In functional stasis the progress may be as slow, but it is obvious that the colonic lumen is poorly filled, portions of the gut between the static seybalia are quite empty. Finally, in chronic obstruction the stenosed passage may be outlined, first with a mixture of barium and feces, and later with homogeneous barium.

INTUSSUSCEPTION

This condition—the invagination of one portion of the gut into the lumen of the immediately distal part, is infrequently referred for X-ray investigation.

In most cases the condition is urgent, the diagnosis obvious, and radiographic examination unnecessary. If there is doubt as to the diagnosis and the condition permits a barium enema may demonstrate the lesion.

The great majority of cases occur in young children and in them constitute a common type of acute intestinal obstruction. It is a rare condition in adults and in them tends to be chronic and intermittent.

Pathological Anatomy — An intussusception consists of three concentric tubes:

- (1) The entering tube
- (2) The returning tube,
- (3) The receiving tube or sheath

The first two constitute the intussusceptum and the last the intussusciens. The junction of the entering and returning tube forms the apex of the intussusceptum and the junction of the returning tube and sheath is called the neck. The mesentery is dragged in between the returning and receiving layers and as it becomes packed therein occludes its contained blood vessels and causes gangrene of the intussusceptum. The drag of the mesentery on the mesial side of the intussusception causes the typical concavity of the tumour mass felt clinically.

Classification — This is based on the portions of gut involved. The common type is the entero colic involving both small and large intestine. Rarer varieties are the enteric and the colic involving small and large intestines respectively. The great majority of cases in children occur in the ileo-cecal region and therefore fall into the entero colic group. Depending on the part forming the apex of the intussusceptum three types occur:

(a) The *ileo-cecal*, in which the ileo-cecal valve forms the apex. This is much the commonest form.

- (b) The *ileo colic*, in which the ileum forms the apex.
- (c) The *cecal* in which the inverted cecum forms the apex.

The various types may be therefore tabulated as follows:

- (1) Enteric
- (2) Entero colic (a) Ileo colic
(b) Ileo cecal
(c) Cecal

(3) Colic

Ladd and Gross have analysed a series of 372 cases in children. The peak age incidence in these was 7 months and the percentage of types as follows:

Ileo-cecal and Ileocecal	74
Ileocecal	16
Cecal	20

In the first majority of the cases the diagnosis was clinically evident. Cases in which there was some doubt were submitted to

barium enema examination. A correct diagnosis was made in sixteen of these. In one an ileo caecal intussusception no colonic abnormality was found.

Radiographic Features—Although the diagnosis of acute intussusception is usually evident clinically and requires no verification the X-ray appearances



FIG. 200.—Intussusception in a child aged 18 months.

(a) The barium enema obstructed by the apex of the intussusception producing the characteristic cupping. (b) After evacuation of the enema traces of barium have escaped into the stool or intestinal lumen.

are so characteristic that a barium enema should be given if there is any real doubt provided the patient's condition permits.

In a typical case there will be noted the following abnormalities (Figs 200-201).

(1) OBSTRUCTION TO THE ENEMA.—The enema runs normally up the colon till it meets the apex of the intussusception at which point it is arrested.

(2) CUPPING OF THE HEAD OF THE BARIUM.—The apex projecting into the arrested barium injection causes an indentation or cupping in the barium shadow at that point.

(3) FILMING OF THE INTUSSUSCEPTION.—The obstruction to the enema caused by the invagination is not usually absolute. Gradually a thin incomplete cylindrical shell of barium spreads between the receiving and return

ing layers of the intussusception. Although theoretically a central streak of barium might escape along the lumen of the intussusceptum, actually oedema usually seems to prevent this.

(4) LOCALISATION OF THE TUMOUR.—By radio-scopye palpation, the tumour felt clinically can be shown to correspond to the barium shell.

(5) RESIDUE AFTER EVACUATION.—Barium tends to remain entangled between the sheath and intussusceptum after the barium has been evacuated.

Several observers have noticed a spontaneous reduction of the intussusception during and apparently as a result of the pressure of a barium enema. This is a fortunate occurrence, and one which can be followed throughout its course fluoroscopically, but it is too uncertain to warrant the use of an opaque enema for that purpose.

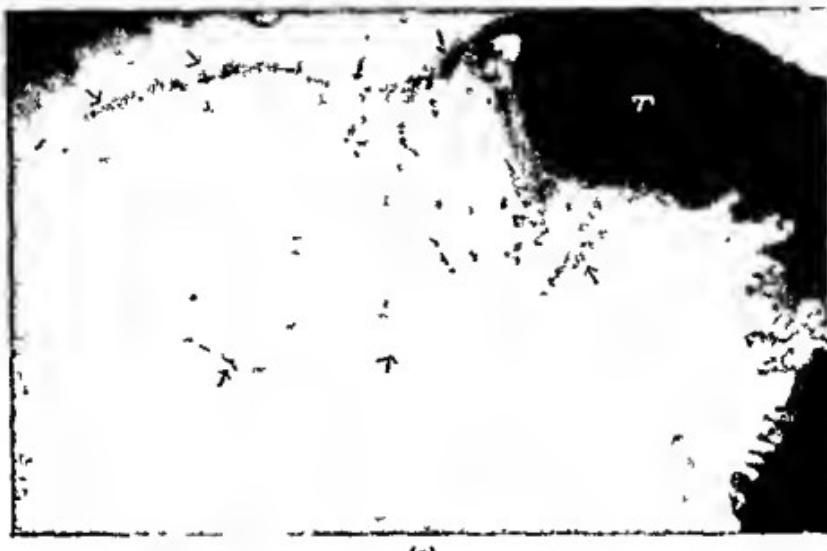
Indeed time is so much the essence of the contract of safety in these cases that none should be wasted even on a diagnostic opaque enema, unless the doubt as to the diagnosis is real. If, however, a diagnostic opaque enema is decided upon it is worth while attempting, by gentle abdominal massage and gentle fluid pressure by the gravity fed enema, to reduce the invagination. The two criteria of success in this manœuvre are the unfolding of the colonie reduplication seen by the filling of its lumen, and the escape of the enema into the ileum. Even if reduction is complete narrowing of the colonic lumen will be evident from oedema of the colonic wall.

After fluoroscopic reduction the child must be kept under very strict observation in case the reduction is incomplete or the condition recurs.

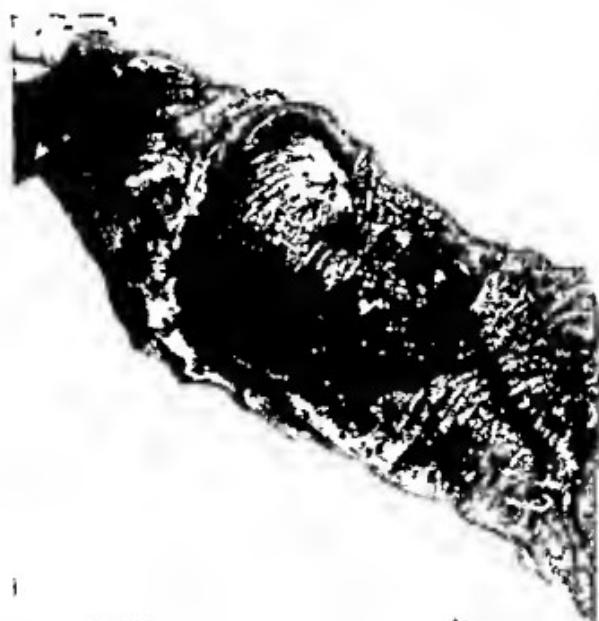
VOLVULUS

The term volvulus is applied to the twisting of a segment of bowel on its mesenteric axis. The sigmoid colon is the portion involved in the great majority of cases—75 per cent according to A. Mills. This segment is particularly prone to volvulus because of the sigma shape of its mesentery. In the greater number of cases the condition constitutes an acute surgical emergency being one of the most fatal forms of obstruction. Not only does the twist obstruct the bowel but it also cuts off the blood supply and causes gangrene of the affected portion.

In a few rare cases the obstruction is incomplete and the vascular supply intact. In these cases of chronic volvulus radiological examination may be of help. The bowel up to the neck of the volvulus can be shown with a barium enema and if any of the enema can escape through the neck a sickle shaped shadow may be visible representing the narrowed first twist of the distal limb of the volvulus. In addition depending on the degree of obstruction gaseous distension may be evident above. Obviously a barium meal might be a dangerous method of examination in these cases.



(a)



(b)

FIG. 201.—(a) Intussusception showing obstruction to the opaque enema in the transverse colon, with coating of the sheath.

(b) The resected specimen

GALL-STONE IMPACTION

Gall stones of a size (1 inch or more in diameter) sufficient to cause obstruction by impaction in the small intestine are usually to some extent calcified and so visible in a radiogram. Except in very rare cases the gall stone reaches the intestine by ulcerating its way through the gall bladder and adherent jejunum and it usually impacts in the lower ileum. The larger it is the higher the impaction. It may therefore be visible in the right iliac fossa in a plain radiogram taken to determine the site of the acute obstruction which is the usual sequela of impaction.

CHAPTER XVIII

TUMOURS OF THE COLON

BENIGN TUMOURS OF THE COLON

SOLITARY TUMOURS such as adenoma, fibroma, lipoma or myoma are rare. They usually become pedunculated and project into the lumen of the bowel. If large enough they may show a mobile central filling-defect with a barium enema but they may easily escape detection by this method. They can be demonstrated with greater certainty by one of the double contrast methods, but even when one of those is used a negative result does not exclude them with certainty.

Multiple adenomata (*syn. polyposis of the colon*) may be present in large numbers and may cover a large portion of the colonic mucosa. At first they are small, flat and sessile but some may grow to the size of a cherry and become polypoid. Clinically they give rise to intractable diarrhoea, painful tenesmus and blood and mucus in the stool. Ulceration and malignant degeneration are common sequelae.

Some indication of the condition may be seen in the contour of the barium enema picture in the form of small rounded indentations but the adenomata are best demonstrated by one or other of the double contrast enemas. With these methods the opaque medium settles in the crevices between the tumour masses and produces a coarse lace or honeycomb pattern which is almost pathognomonic (Fig. 202). As the muscular coats of the bowel are not involved the lumen is not narrowed and the normal haustration is present.



L = Amp. Rx S = sigmoid D = descending colon

FIG. 202.—Diffuse polyps in the sigmoid.

CARCINOMA OF THE COLON

This is a common disease and one in which the help of the radiologist is sought as a routine. The sigmoidoscope is within its ambit the conclusive diagnostic method but radiology is the most accurate method for the colon above the reach of that instrument. The method of choice is the barium enema for reasons already enumerated.

Morbid Anatomy

From the radiological point of view it is the macroscopic varieties which are important.

The commonest type is the *aderocarcinoma* originating in Lieberkühn's glands. This may form a tumour mass projecting into the lumen which commonly ulcerates sooner or later.

The *scirrhous* type tends to encircle the bowel and produce a stenosis. The contracture may involve a segment of the gut 2-3 inches in length or be limited to a very narrow zone—the string carcinoma. Frequently a ~~mix~~^{blot} of these macroscopic types occurs with projection of a tumour mass into the colonic lumen scirrhous contracture of its wall and an ulceration of the projecting tumour or the colonic wall. In the stenosing type the channel may be reduced to a crow quill without acute ob traction supervening.

The bowel above the lesion is frequently dilated and hypertrophied.

Site

The pelvic colon is the commonest site of carcinoma next the cecum and ascending colon then the transverse colon and splenic flexure and lastly the hepatic flexure and descending colon.

Anschut and Korte have reported the following site incidence in a series of 377 cases:

	Percent
Sigmoid	43.8
Cecum and ascending colon and hepatic flexure	3.6
Splenic flexure, transverse colon	14.1
Descending colon	1

Radiographic Features

The cardinal feature is the presence of a filling defect in the barium shadow. The other signs are the presence of colonic obstruction, fixation of the gut, enterospasm and disturbance of the colonic mucosal pattern.

THE FILLING DEFECT—This may be of various types depending on the size, shape and type of the growth. A tumour which projects into the lumen produces a defect of the *finger print* type similar to that produced by an epiphiloid carcinoma of the stomach. The contour of the gut is almost invariably involved also because of the relatively small lumen. If only a central filling-defect is visible faecal accumulation or a polypus is much the

more probable explanation. In the cæcum however the wider lumen may result in only a central defect being visible.

In the majority of cases the filling defect takes the form of an irregular narrowing of the bowel. The *napkin ring* defect is a very typical appearance. In this the normal lumen is abruptly interrupted by a narrowed portion of 1-3 inches. This narrowed portion is commonly slightly eccentric due to the greater mass of the tumour at its point of origin. Two features of this type of filling defect are its sharply defined and rather jagged or irregular outline and its constancy. These distinguish it from a localised colospasm.

When the annular scirrhouss growth is limited to a very short segment of the bowel the type known as the *string* defect is produced as though a ligature had been tied round the colon. Even in this localised defect the contours of the bowel where they dip down to the constriction give evidence of their involvement in the growth by their slight irregularity and by the constancy of that irregularity in a series of radiograms. The constancy of these defects is an important point in their evaluation can be tested by superimposition of the radiograms. Although perfect fusion is usually not obtained by this procedure the deformities will show the same geographical features.

Graham Hodgson has drawn attention to a simple test for the constancy of a filling-defect—that of taking two exposures on one film at an interval of some few seconds. The normal portion of the barium filled gut will show a double outline owing to peristaltic action—the filling defect either carcinomatous or diverticular will not.

Attention to one type of filling defect has been drawn by *Lockhart Mummery*. It results when a sessile adeno carcinoma ulcerates in the centre. When this is seen in profile there is a double encroachment of the colonic lumen since the edges of the crater are somewhat raised. In contradistinction to this the papillomatous growth produces a rounded filling-defect.

THE BARIUM ENEMA is the method of choice for the demonstration of a carcinomatous filling defect. Only by it can the whole of the large bowel be filled with certainty and even when filled certain coils tend to overlap and obscure each other. In the sigmoid this is a common occurrence and a growth just above the rectosigmoidal junction may be completely hidden in a postero-anterior view. The right oblique view usually separates these two shadows and should be used as a routine in all barium enema examinations. Occasionally the left oblique view is more effective because of the disposition of the sigmoid and if the former oblique fails to show a satisfactory separation of the coils observed fluoroscopically the other should be tried.

At the splenic flexure a similar reduplication of the two limbs commonly occurs and this region presents the further difficulty that it is quite inaccessible to palpation. Again the optimum degree of rotation must be determined by screen examination but as a rule the left oblique position is the best.

The hepatic flexure is accessible to the palpating hand and a lesion there is



FIG. 203.—Annular carcinoma of the descending colon



FIG. 204.—Non-carcinomatous changes of the sigmoid showing finger print defects

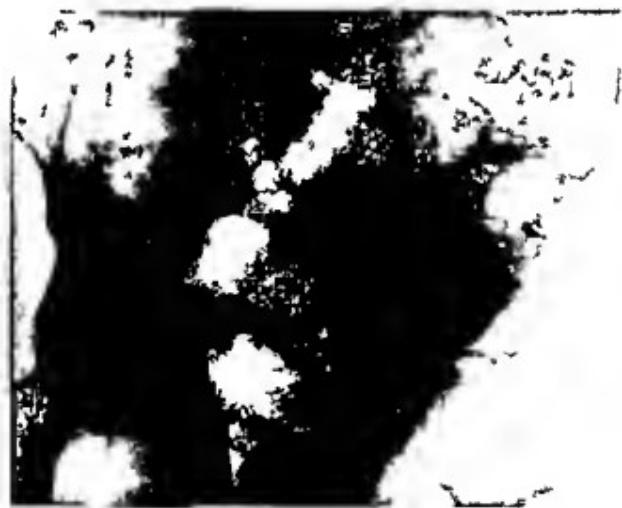


FIG. 205.—Annular carcinoma of the sigmoid as seen in the second stage of a thorium dioxide enema. The mucosal pattern is absent in the affected segment

more easily detected. *The cæcum often presents some difficulty, because of the size of its lumen and the difficulty of filling it uniformly.* In spite of thorough preparation, the cæcum may contain a considerable quantity of fluid faeces, which dilutes the barium injection and causes a mottled or irregular shadow. Careful fluoroscopic palpation should reveal the inconstancy of this appearance, and so its nature.

APPEARANCES WITH THE THORIUM FLOCCULENT ENEMA—In some cases a small *encephaloid carcinoma* is hidden by the overlaid shadow of a barium



(a)



(b)

FIG. 206.—Encephaloid carcinoma of the sigmoid.

(a) Filling defect in the filled colon (b) Relief pattern of the tumour after evacuation of the enema

enema. It is in such that the collapsed and inflated stages of a thorium enema may be of value.

The segment of the colon invaded by the tumour is rigid and does not collapse readily. If by posture and massage it can be made to empty itself, gas is apt, according to Maingot, to accumulate there. No plicae are visible in an invaded area. In their place is an irregular disorganized areolar arrangement, with clear areas and opacities corresponding to the tumour masses and the interstices between.

Inflation with air shows the tumour mass in greater relief, an effect further enhanced by stereoscopic radiograms. The inflation also reveals the extent of narrowing of the bowel resulting from the neoplasm.

The *annular scirrhoue carcinoma* of the colon is usually so evident with a barium enema that it is unnecessary to use the more complicated method, unless overlapping of coils obscures the lesion.

The stenosed passage is of course clearly visible by the thorium method. Collapse of the gut above the growth is usually prevented by the stenosis present. That below the growth collapses normally and shows a normal mucosal pattern or one showing a reflex reactive state. The stenosed passage shows no pliée. Air inflation shows up the stenosis with particular clarity.



FIG. 707.—Scirrhoue carcinoma of the cecum and ascending colon with fecal obstruction shown by a barium meal 7 hours after ingestion. This patient had at the same time a scirrhoue growth of the stomach.

DIFFERENTIAL DIAGNOSIS OF THE FILLING DEFECT.—Several other conditions may produce a gap in the barium shadow notably diverticulitis, advanced ulcerative colitis, fecal tuberclosis, actinomycosis, simple tumours, circumscribed appendicitis, abscess, colospasm, fecal concretions and gas. Most of these are recognisable but difficulty may arise with caecal tuberculosis and actinomycosis. It may be quite impossible to differentiate radiographically between cancer tubercle and actinomycosis of the cæcum and the decision must then be arrived at on clinical evidence or biopsy.

In the cæcum the site where the greatest difficulty arises in the differential diagnosis certain features may be of help.

The double contrast enema either barium or thorium finds its particular sphere of usefulness in the doubtful case—one in which there is say an unexplained colonic haemorrhage and in which an ordinary barium enema reveals no cause for the bleeding. If by the more complicated procedure an occasional early carcinoma is discovered the method is well worth using even although many a blank is drawn. Because of the possibility the method constitutes a definite advance in the early diagnosis of carcinoma coli.

Encephaloid growths cause a ragged, worm-eaten filling defect. Scirrhous growths produce a more regular contracture closely similar to cecal tuberculosis, an appendix abscess causes a smooth regular one. Ileal stasis may occur in all three in the following descending order of intensity—carcinoma, abscess, tuberculosis.

Any bubbles of gas that may be present during a barium enema tend to collect, in the supine position, at the apices of the colonic watersheds, namely the highest loop of the sigmoid and the middle of the transverse colon. They are distinguishable from neoplastic central filling defect by the absence of any deformity of the wall of the gut, and by the fact that they are more transparent than the surrounding soft tissues. Change in posture—e.g. to the prone—completely alters their disposition.

Faecal accumulations and concretions may cause more difficulty, and re-examination may be necessary.

The distinguishing features of diverticulitis, ulcerative colitis, pedunculated simple tumours, and colostomies are described under their respective sections.

OBSTRUCTIVE SIGNS IN CARCINOMA OF THE COLON—Too often this feature is so marked when the patient first seeks advice, that radiology is not employed, the case goes straight to the theatre as an emergency. Of the balance the majority show some evidence of stasis above the growth. In many of these the degree of obstruction is sufficient to make the use of a barium meal unwise, but in other milder degrees the barium meal may be safe, and give useful evidence as to the degree of back pressure.

The general radiographic signs of colonic obstruction are described elsewhere, and it remains only to be said that in carcinomatous obstruction the actual obstructing lesion can be demonstrated by a barium enema in all but the most severe cases—those bordering on the acute.



FIG. 208.—Carcinoma of the cecum causing a filling defect thereof. Laparotomy revealed secondary deposits in the liver.

FIXATION OF THE GROWTH—This as determined by radioscopic palpation during an enema examination is a late sign. In the early stages the affected portion of the colon shows normal mobility, and only when the neoplasm has

spread to surrounding structure does fixation take place. Its chief significance is therefore as an indication of operability or the reverse.

ENTEROSPASM—In certain cases ulceration of the growth causes adjacent spasm of the circular fibres which modifies the filling-defect. It is seen especially in the sigmoid and may cause a temporary obstruction to the enema. Intermittent application of the normal gravity pressure of the enema usually causes a relaxation. The practical importance of this spasm is in the difficulty it may cause in demonstrating the more serious underlying lesion.

Perforation of a Carcinomatous Ulcer

This constitutes a surgical emergency and the only occasions on which this is demonstrable radiographically are when the perforation occurs accidentally during the course of a barium enema examination. This mishap may take place without any undue enema pressure if the ulcer is already near the point of perforation and constitutes a warning against

FIG. 209.—Case no. 9 of the lower end of the colon with recent perforation.

using too high a gravity head in the administration of the enema. The fluoroscopic appearances are characteristic—the barium is seen to pass along the colon normally to the point where perforation occurs and thence in a flood into the peritoneal cavity.

The only thing that can be said in mitigation of this unhappy occurrence is that the inevitable perforation is discovered at the earliest possible moment.

SARCOMA OF THE COLON

This is a rare disease and is most frequently met with in young subjects. It usually involves the cecum. It tends to infiltrate the bowel wall and convert it into a rigid tube. Obstruction is a late phenomenon. It is impossible to differentiate it radiographically with any certainty from a carcinomatous growth.



CHAPTER XXIV

DIVERTICULITIS OF THE COLON

CLINICAL FEATURES

Definition—This condition consists in the presence of small protrusions of the mucosa through the muscular coat and the formation thereby of small saccular pouches. Inflammatory changes commonly supervene in and round the diverticula.

Terminology—Although the term *diverticulitis* is commonly used to include all the stages that occur in this disease it is convenient to describe the pre-inflammatory stage as one of *diverticulosis* and to restrict the term *diverticulitis* to those cases in which inflammation has occurred and which consequently give rise to symptoms. If the view of *Spriggs* is accepted to those there may be added the pre-diverticular stage.

Aetiology—The precise cause is unknown. It is a disease of the later decades of life; few cases occur before the age of 40 and its incidence is progressively greater with increasing years. In the writer's experience males are more commonly affected than women and the condition is much more common in private than in hospital practice. A spastic condition is held by some authorities to be a factor in initiating the early mucosal herniation and the imperfect nature of the outer muscular coat of the colon doubtless makes it easier for the protrusion to occur.

Spriggs found in 3,000 barium meal or enema examinations that 10 per cent showed evidence of diverticulosis and 2.3 per cent evidence of diverticulitis. Associated cancer was found in only four cases. This last is within the limits of coincidence. The average age was 56, the ratio of men to women was 34:16 and one third of the patients were obese.

PATHOLOGY

The protrusion commences as a tiny V-shaped mucosal process which wherever it passes through the inner muscular coat enlarges into a flask- or currant-shaped saccule with a narrow neck. The herniation always takes place along the edges of the tenia (at points where the blood vessels penetrate the muscular coat) and never through them. The wall of the diverticulum is therefore formed of innervous submucous and peritoneal coats. Sometimes the diverticulum penetrates an appendix epiploica and so acquires a fatty coat as well.

The diverticula range in size from 1 or 2 mm. to about 2 cm. The majority

are about $\frac{1}{2}$ -1 cm in diameter. They are generally held to be pulsion diverticula herniating through weak points in the bowel wall. Their tendency to develop above a colonic stricture is quoted by *Lockhart Mummery* in support of this view.

Site—Diverticula may occur anywhere in the cecum and colon but by far the commonest site is in the iliac and pelvic portions. The most frequent distribution is a considerable number in the sigmoid and a few scattered elsewhere. Usually they become progressively fewer as the colon is traced upwards. In a number of cases they are limited to the sigmoid and even when they are also present elsewhere the stage of the disease is more advanced in that segment the diverticula are more numerous larger and inflammatory changes if present more severe. Occasionally a diverticulum may develop in the appendix. According to *Lockhart Mummery* they do not tend to develop pathological changes in this situation. This is a curious fact if true in view of the tendency to formation of concretions in the appendix itself.

Inflammatory Changes—Sooner or later in the majority of cases the stage of diverticulitis is reached. The changes are almost exclusively limited to the descending iliac and pelvic portions and especially to the latter. The inflammatory stage is initiated by stasis in the diverticula. Seybals tend to form in the pouches and if they become sufficiently impeded they are retained and set up catarrhal changes in the same way that an appendix does if it contains a concretion.

These early inflammatory attacks may subside without causing much structural change again as in catarrhal appendicitis but in time the submucosal coat becomes involved by the formation of minute intra mural abscesses. The wall of the gut adjacent to the diverticula also shares in the process. The peritoneum reacts to the irritation in the form of a plastic peritonitis. In an established case it becomes thickened and the diverticula tend to become partly or completely submerged in the hyperplasia. The same process causes a narrowing of the lumen of the gut. In all but the advanced cases some of this narrowing seen radiographically is however due to spasm of the circular muscular coat and only part to organic stenosis. The inflammatory hyperplasia accounts for the sausage shaped tumour which is frequently found on clinical examination. Peritoneal adhesions commonly occur in the later stages resulting in fixation of the affected segment. Perforation of a diverticulum or of an intra mural abscess may occur but because of the adhesions general peritoneal infection is not so common as in a perforated appendix. The perforation may take place into the bladder or may result in a localised abscess.

Stenosis of the colon commonly results when the stage of the sausage tumour is reached. It may however occur from pericolonic adhesions or from a smooth intrinsic fibrotic stricture without hyperplasia. In this last type the diverticula may be so compressed that they do not fill with a barium

enema and the narrowing may be mistaken for a scirrhous carcinoma This is the type most amenable to surgical excision

Lockhart Mummery has summarised the complications of diverticulitis as follows

- (1) Tumour formation
- (2) Abscess intra mural or pericolonic
- (3) Colonic stricture
- (4) Pericolonic adhesions
- (5) Fistulae especially vesico colic
- (6) Carcinoma (he holds that diverticulitis predisposes to carcinoma, view at variance with those of Spriggs)
- (7) General peritonitis
- (8) Contracture of the mesosigmoid

RADIOGRAPHIC TECHNIQUE

The preparation of the patient by aperients and colonic lavage is important, the object being to empty the diverticula. If there are clinical signs of active peridiverticulitis with the presence of a tumour mass it is unwise to use drastic purgation. The diverticula are devoid of a muscle coat other than the muscularis mucosae and it may be difficult to ensure their emptying by any preparation if their contents are inspersated. This difficulty may be turned to advantage in estimating the severity of the condition since stasis in the diverticula is of clinical significance and the stasis can be demonstrated in a barium enema by the bubble or flask sign.

Two methods of investigation are available—the barium meal and enema.

Those who favour the *barium meal method* state that it fills and so outlines the diverticula with greater certainty than the barium enema and this is probably true. The meal also indicates the degree of colonic stasis above the inflamed segment. It has however several disadvantages. (1) It may aggravate a chronic obstruction. (2) It usually fails to give an accurate picture of the degree of the inflammatory change present and of the extent of the stenosis. (3) If only a few diverticula are present it may be difficult to distinguish between them and intra luminal scybala. (4) The examination may last several days.

The *barium enema* suffers from two theoretical objections—namely that the diverticula do not always fill so well and that the widely filled colonic lumen may mask some of the diverticula. It is very rare however in the writer's experience that none of the diverticula are filled with a barium enema and failure to fill some of them is not of serious importance. The masking can be minimised by taking radiograms in different planes. The enema gives accurate information regarding the diverticular filling-defect shows a pre-diverticular spasm fills the majority of the diverticula and demonstrates diverticular

seybala. Most of the advantages afforded by the meal method can be attained by examining the patient again twenty four hours after the enema examination.

In the writer's opinion therefore the barium enema should be the method of choice in all cases of diverticulosis and diverticulitis and the meal reserved for cases in which the enema fails to elucidate the condition satisfactorily. The enema should be administered in the ordinary way under fluoroscopic control and particular attention paid to the pelvic and iliac portions of the colon. The diverticula if small may be difficult to see under the screen but any stenosed segment is usually visible and its mobility and tenderness to palpation should be tested. Radiograms in the postero anterior and oblique views should be taken and one immediately after evacuation of the enema. The examination is usually completed by a further radiogram twenty four hours later.

If the barium meal is used the chief point of importance is that the examination should be continued day by day until the colon is clear of barium leaving only the barium filled diverticula. This may take as long as a week and the demonstration may be rather academic for the trouble and expense involved.

In cases of difficulty and particularly when it is desirable to decide a doubtful associated inflammatory change in a case of diverticulosis the double contrast barium air enema may be used or better still the thorium air three stage enema. The particular advantage of the latter is the indication it gives of the number of diverticula and the state of the surrounding mucosa. Early inflammatory changes can be detected by this method when the ordinary barium enema gives no indication of their existence.

RADIOGRAPHIC FEATURES

The barium enema gives such a wealth of information about a case of diverticulitis compared with the barium meal that it is convenient to describe the enema appearances first and then to add any additional points demonstrable by the other method. It is also convenient to describe the appearances stage by stage although in my one case several stages may be present contemporaneously at different sections of the colon.

(1) The Pre-diverticular Stage.—This has been fully described by Spriggs. It is shown by a barium enema only and consists of fine spastic notches either grouped on the summits of the faecal bulges or replacing those bulges (Fig. 210 (a)). They are not uncommonly seen in early cases of diverticulosis in segments of the colon which are devoid of visible diverticula. Their significance is the subject of some difference of opinion. Barclay attaches little importance to the appearance. Spriggs holds that it is a true pre-diverticular stage spastic in nature and that the minute spikes represent the incipient herniation of the mucosa. Lockhart Mummery, Graham Hodson and Duley have shown by histological section that the tiny notches are

actually due to this beginning herniation. In his clinic, Spriggs has had the opportunity of observing (a) some of these cases over a number of years and has noted the subsequent development of diverticula in segments of the colon which previously presented the spastic appearance. In the present stage of our knowledge the theory he holds provides the most reasonable explanation.

The tendency to colonic spasm in diverticulitis is borne out by the difficulty

Fig. 210.—Diagram of (a) Prediverticular spasm (b) Developed diverticula with saw tooth effect and alternate notching

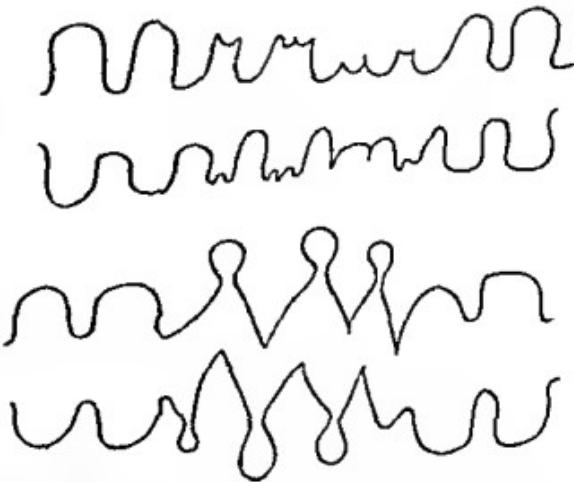


Fig. 211.—Diverticulosis

X R 11-19

that is frequently experienced in administering the barium enema in these cases. In many cases the sigmoid goes into spasm as soon as the rectum is filled so much so that these cases acquire an unhappy reputation amongst the nursing staff of the X-ray department!

(2) Stage of Diverticulosis—This is characterised by the presence of barium filled diverticula, rounded opacities, varying in size from 1-2 mm to 1-2 cm and connected to the colonic lumen by a narrow neck (Fig. 211). An apt simile is a currant with its stalk. Some of the diverticula may already be so completely filled with stercoliths that only the stalk fills with barium. More commonly a film of the opaque emulsion coats the surface of the contained stool ball and produces a characteristic ringed shadow like a bubble or

glass flask. Frequently only the proximal half of the diverticulum is coated barium creeps half round it, and produces a characteristic crescentic or "wine glass" shadow.

(3) Stage of Diverticulitis.—It is not until this stage is reached that symptoms of any consequence arise, and its recognition is of some importance (Figs 212-214). It is characterised by changes in the lumen of the bowel rather than in the diverticula. *The changes in the diverticula, if any, are an increase in the*



FIG. 212.—Sigmoid diverticulitis shown by a barium enema. The saw-tooth notching is visible in heating the inflammatory stage.

number of flask shadows and the obliteration of some of them. *The changes in the lumen are quite distinctive in a developed case.*

(a) It is narrowed.

(b) It presents a jagged or saw tooth contour, the apices of the teeth coinciding with diverticular necks. A very characteristic variation of this appearance is an alternate notching with a diverticulum at the intervening peaks. This gives the narrowed lumen a zigzag shape (Fig. 210). In advanced cases the diverticula may be obliterated at the site of the inflammatory changes and the appearance may then resemble a carcinomatous filling defect.

Usually however, there is sufficient of the notched or saw tooth appearance to indicate the true nature of the condition even if no diverticula are visible elsewhere. In this class of case the barium meal may be of real help in filling diverticula which are impervious to the enema.

(c) An important feature of the inflammatory change is the constancy



Fig. 11.—Brazilian cattle in a steep, rocky, overgrown hillside.

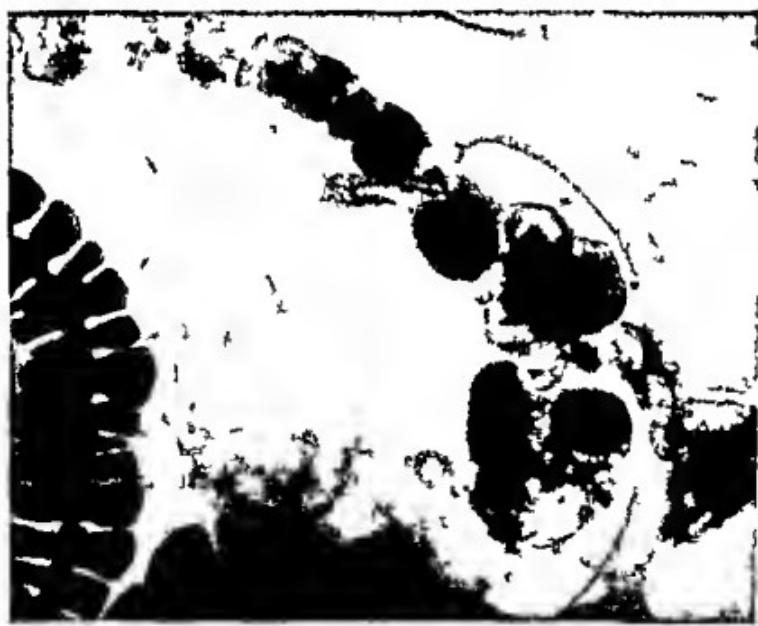


Fig. 12.—Same hill as Fig. 11, showing a large, irregular, dark mass.

of the filling defect. Superimposition of a series of radiograms reveals an identical outline in each allowing for variations in the distension of the lumen by the enema. In the well marked case even considerable distension fails to produce any change, since the walls are thickened, fibrosed, and inelastic. The spastic phenomena on the other hand, are susceptible to some alteration from variations in distension and spastic tonus.

The double-exposure method described by *Graham Hodgson* is useful in demonstrating the constant inflammatory deformities of contour. It consists in making two light exposures on the same film at a few seconds' interval.

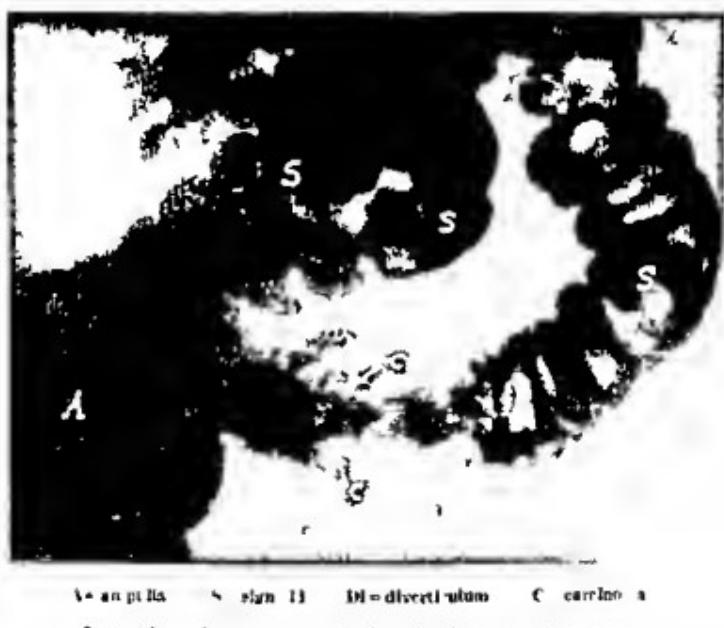


Fig. 215.—Carcinoma and diverticula in same case.

Slight alteration is seen in the normal bowel and none in the diverticular segment although not necessary in every case it is of help in a case of doubtful inflammatory change.

Carcinoma may coexist with or supervene on a diverticulitis and may then present a very difficult diagnostic problem (Fig. 215). Since the primary disease can produce a radiographic filling defect similar to a carcinomatous one (even to obliteration of the diverticular shadows) it is usually difficult and sometimes impossible to detect from the radiographic appearances the occurrence of this serious complication. The only safe course in a case of serious doubt is to act on the assumption that the worst has happened, and that a cancer has developed on top of the original lesion.

PERFORATION—Perforation into the free peritoneal cavity is an acute surgical emergency one which does not pay a visit to the X-ray department en route for the theatre. Perforation into the bladder is readily recognisable



Fig. 216.—Perforation of diverticulum into the bladder.

clinically, and can be demonstrated radiographically by the passage of a contrast medium from one viscous to the other (Fig. 216).

Appearances after a Barium Meal

The patient should be examined twenty-four hours after taking the meal, and on succeeding days as necessary.

This method shows the diverticula very well and demonstrates colonic stasis if present, but gives little or no information regarding inflammatory changes. In a well-marked case the diverticula are seen filled with barium after the main lumen of the bowel is clear and cannot be mistaken for anything else (Fig. 217). If only one or two opacities are present it may be difficult to determine whether they really are in diverticula. Barium in a diverticulum is extra-luminal and to prove that it is outside the colon proper the lumen of the latter must be fully outlined. Because of a tendency on the part of barium sulphate to cake these diverticular shadows may remain for several days, a further point distinguishing them from stool. Stasis of barium in them should not be regarded as evidence that similar stasis occurs with ordinary faecal contents. A better index of real diverticular stasis is the flask shadow mentioned above.

Appearances after a Thorium Three-stage Enema

STAGE OF DIVERTICULOSIS.—The diverticula are the only abnormalities seen. Their appearance in the *first stage* is the same as that in a barium enema. After evacuation the mucosal pattern is normal except for a corona of pecten which occasionally surrounds the ostium of the diverticulum. After inflation the diverticula may present a variety of appearances.

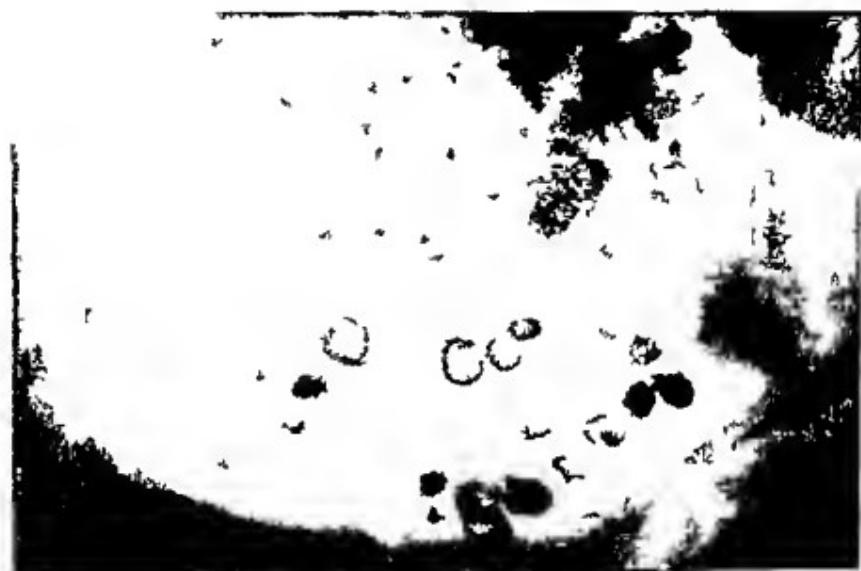


FIG. 1. Barium filled rectum & diverticula 48 hours after an oil meal showing the typical flask shadows.

- (1) Thorium filled and seen in profile
- (2) Thorium filled and seen *en face*. They then appear as rounded opaque shadows in the intermarginal zone
- (3) Air filled and presenting an opaque flocculent lining. They then show a typical flask appearance
- (4) Half filled with air half with thorium. They then appear as dark round opacities unless examined with the subject erect when they show a fluid level
- (5) Air filled and containing a concretion. Three zones are then visible—the central concretion, the clear air space around it and the dark flocculent lining on the surrounding mucosa

The mucosa of the colon itself is normal in appearance in diverticulosis.

STAGE OF DIVERTICULITIS.—The diverticula appear exactly as above described except that retention of concretions and sepsis is much more common.

It is in the *intervening mucosa* that the changes indicative of the inflammatory process appear. The mucosal pattern is difficult to produce since flocculation occurs with difficulty as a result of the associated colitis. This also prevents complete and even collapse in the second stage of the examination.

In the first degree of associated peridiverticulitis the pattern is a little distorted the plicae fewer in number and rather thick. As the inflammation increases in degree these changes increase until virtually no plicae are visible at all.

The third stage of the examination—infarction—reveals the rigidity and narrowing of the affected segment and the opaque marginal line is thick irregular and denticulated. The intermarginal zone shows irregular opaque plaques in place of the normal crazing.

The colon distant from the affected segment commonly shows changes—as a rule increase in number and thickening of the plicae. This is a reflex reaction in the muscularis mucosae—the *état irritatif* of Mairgot.

The bowel generally may show considerable spasticity again a reflex from an inflamed area of diverticulitis. This spasticity in a region remote from the actual lesion may give an indication as to the degree of the inflammation and may often be seen to disappear as the acute focal inflammation subsides.

RADIOGRAPHIC CONTROL OF TREATMENT IN DIVERTICULITIS

Medical Treatment—Medical treatment is in the early stages prophylactic and is directed to keeping the stools semi liquid. So long as stasis in the diverticula is prevented the condition is innocuous. The measures usually advised are a diet with little residue and sufficient doses of liquid paraffin or paraffin and agar agar to ensure that the stools shall never be of a firmer consistency than cream. If paraffin does not agree mild aperients and salines are employed with the same object. The efficacy of these measures may be tested quite simply by giving the patient a barium meal and taking radiograms seven and twenty four hours after and subsequently as required. If the diverticula are clear as quickly as the main colonic lumen the measures taken are satisfactory. If not a stricter regimen should be adopted.

Surgical Treatment—In some advanced cases it is necessary to perform colotomy usually in the transverse portion. This relieves the condition entirely as long as the colostomy is open the patient is quite safe closure on the other hand is associated with some risk of recrudescence of the disease.

In these cases after six to nine months the problem of closure of the colostomy must be decided. By then all inflammation will have settled down and further delay involves risk of too marked contracture of the bowel to allow of closure.

A barium enema is an essential preliminary to answering the following questions:

(1) Is the inflamed segment too stenosed to allow closure of the colostomy without resection of the stricture?

(2) If resection is necessary to permit of closure is the bowel above and below the condemned segment sufficiently healthy and is there enough "flesh" to allow a satisfactory anastomosis?

Plain closure of the stoma without preliminary resection is possible only in a few cases. It is usually necessary first to resect the stenosed segment followed a month or so later by closure of the transverse colostomy and again a barium enema examination should be made of the sigmoid anastomosis before the stoma is closed.

CHAPTER XXV

THE RECTUM AND ANUS

ANATOMY OF THE RECTUM

THE RECTUM consists of that portion of the alimentary canal from the recto-sigmoidal junction to the anus. It is variable in length, the average being 4-6 inches.

It begins to the left of the midline opposite the third sacral segment, and runs down in the midline in the hollow of the sacrum to a point 1 inch in front of the tip of the coccyx where it joins the anal canal. When empty and collapsed it occupies the sagittal plane, and shows a curve with the concavity forwards similar to that of the sacrum. The middle portion of the rectum is very distensible and is therefore sometimes called the ampulla. This degree of normal distensibility is well seen in a barium enema, or after a barium meal in a case of dyschezia. When distended, its lateral contours are indented by the valves of Houston.

The valves of Houston are three in number, and are radiologically important since they cause indentations in the rectal shadow. They are crescentic folds of mucosa, each passing with a slight diagonal turn round two thirds of the rectal circumference. They are inconstant in their position, but in general are arranged in a tier *en échelon*. Lockhart Mummery has described them as with their free edges overlapping like a photographic diaphragm. The uppermost is the most constant, and is situated anteriorly at the level of the peritoneal reflection. The lower two cause slight regular notches in the convex lateral contours of the distended rectum. The rectum as it approaches the anus, curves gently forwards and finally turns abruptly downwards and backwards into that canal.

CARCINOMA OF THE RECTUM

It is possibly an overstatement to say that radiology should play no part in the examination of the rectum. Even if it is so, the statement serves to emphasise that fingerstalls are cheap, and that sigmoidoscopy is a simple procedure. If this seems to labour the obvious the writer's excuse is that on several occasions he has been requested to make a barium enema examination for suspected carcinoma recti, before even a digital examination has been made. A barium enema examination may be necessary to determine the condition of the bowel beyond the reach of the sigmoidoscope, or the degree of dilatation above an already detected rectal growth, but to employ it to detect such a growth

itself is not only waste of an expensive method, but is also dangerous, since it may not demonstrate the lesion.

With this caution it is permissible to consider what radiographic signs may be given by cancer of the rectum during the course of an opaque enema examination.

The most constant change is diminution in size, the ampulla fails to dilate to its normal contour, in all but the smallest growths.

This is the result of the inelasticity of the infiltrated portion of the rectal wall (Fig. 218).

If the growth is limited to the posterior wall this may be the only change in the postero anterior view. The rectum then gives a "justo minor" appearance, as the filling defect on the posterior wall is masked by the barium in front of it. The semi lateral view may bring the irregular defect into view, but not with certainty. If the growth is on the lateral wall the filling defect will stand out clearly unless masked by the sigmoid. After evacuation of



FIG. 218.—Circumferential carcinoma of the rectum.

the enema it may be possible to see the irregular contours of the growth coated with barium particularly if some air be injected.

SIMPLE STRICTURE OF THE RECTUM

This, if severe, is an exception to the above rule. Radiology may be an essential step in estimating the extent and degree of the narrowing, if neither finger nor proctoscope is admitted.

There are four classes of simple stricture—congenital, traumatic, spastic, and inflammatory.

THE CONGENITAL type commonly occurs at the mucocutaneous junction of rectum and anal canal—the union of proctodeum and hindgut. It may vary from complete atresia to slight narrowing.

TRAUMATIC STRICTURE is a type likely to require radiographic investigation and can result from a variety of causes, among which may be mentioned

wounds, cicatrisation after Whitehead's operation for piles, accidental injection of boiling or caustic enemata, and fibrosis following radium irradiation of carcinoma recti.

SPASMODIC STRICTURE is a rare disturbance of the neuro muscular mechanism. Although many authorities deny the existence of this condition, it has been authenticated by *Lockhart Mummery*.

POST INFLAMMATORY FIBROUS STRICTURES form the largest group. This is a common sequela of septic proctitis. The exciting cause may be post operative sepsis, septic proctitis following dystocia, old gonococcal infection, syphilis, dysentery, or bilharzia haematoëma.

It is not to be expected that X ray examination can do more than demonstrate the presence of the stricture. The cause must be determined by the anamnesis and clinical features of the case. The X ray investigation is possible only if the stricture will admit a rubber catheter, but this it usually does. If a catheter will not pass, acute obstruction is close upon the patient.

The injection of the opaque solution should be closely watched under the screen, and gentle pressure only should be used, since the bowel above the stricture may be very dilated and thin. In addition, the colon above the stricture should not be filled too full. If distended, it may overhang and mask the stenosed rectum. Antero posterior and both oblique radiograms should be taken to obtain as full a view of the narrowed passage as possible, and stereoscopic views may be very helpful.

The success of the treatment of rectal stricture, be it by bougies, internal proctotomy, proctoplasty, or excision, may obviously also be checked by X ray examination after an opaque injection.

FISTULA IN ANO

Fistula in ano is not ordinarily a condition in which radiographic investigation is used. As a rule the surgeon is able to follow the course of the fistula without difficulty by other methods.

Occasionally in cases in which there is a deep seated and complicated track, its ramifications may be demonstrated in stereograms after the injection of an opaque medium. Either lipiodol or a sterile barium cream is a satisfactory medium. The latter is to be preferred if there is difficulty in retaining the medium in the fistula, since its viscosity can easily be increased.

If the fistula is blind, it is usually easy to fill the track completely, but if the track has an internal communication with the rectum this may not be possible. A syringe with an olive tipped cannula should be used. It may be possible to seal the mouth of the fistula with adhesive plaster, but often the ostium is too deeply placed in the natal cleft, and no attempt has to be made to occlude it by holding the olive of the syringe against it during the exposures. A metal rectal bougie placed in the anal canal affords a means of orientating

the visualised track in the stereograms. Stereoscopy is essential and a routine technique should include stereoscopic antero posterior views and also a lateral

CONGENITAL MALFORMATIONS

Of the congenital malformations of the rectum and anus, some are not susceptible to radiographic demonstration, since the alimentary canal ends blindly. Theoretically, two could be demonstrated, although there appears to be no record of this having been done. For the sake of completeness they might be mentioned.

(1) *In the male* the rectum opening into the urethra just below the uterus masculinus by a narrow channel through the prostate.

(2) *In the female* the rectum opening into the navicular fossa of the vulvar cleft behind the vaginal orifice.

Both these result from a persistence of the original communication with the cloaca and are, according to Clogg, the commonest forms of rectal malformation.

REFERENCES

- ALVAREZ, W C., and IREDFENDER, B L., *J Amer Med Ass.*, 1924, LXXXVIII, 575
- BARCLAY, A J., *The Digestive Tract*, London, 1930
- BENNETT T LEOD, HUNTER, D and VALCHAN, J M., *Quart J Med.*, 1932, XXV, 603
- BLIG, A., *Rontgenuntersuchung am Innere des Verdauungskanals*, Leipzig 1930
- CANNON, W B., *Amer J Physiol.*, 1901-2 VI, 251
- CASE, J T., *Amer J Roentgenol.*, 1929, XXI, 207
- CLOGG, H L., *Choyses System of Surgery*, London 1932, II
- CRAVEN, A W., *Amer J Roentgenol.*, 1927, XVII, 416
- CRONK, B B., GINSBERG, L., and OFFENBACHER, G D., *J Amer Med Ass.*, 1932, XCIX, 1221
- FRANCONI, G., *Dtschr Med Wschr.*, 1930, XLVI, 1948
- FYFE, W W., *Brit Med J.*, 1903, I, 250
- GASKELI, W H., *The Involuntary Nervous System*, London, 1920
- GILBERT, R., and BABIAK, L., *J Radiol Fleet*, 1934, XVIII, 391
- GOON, L P., *Arch Surg.*, 1931, XXII, 307
- GOTTHEINER, V., *Ergbn Med Strahlenforsch.*, 1928, III, 425
- GRIFFIN, D M., *Edin Med J.*, 1925, XXXII, 175
- HODGSON, H GRAHAM, *Proc R Soc Med.*, 1928, XXI, 1551
- HOUHNNER, K., *Rontgenpraxis*, 1934, VI, 677
- HOLZKNECHT, G., *Munch Med Wschr.*, 1909, LV, 2401
- HUPST, A F., *Brit Med J.*, 1925, I, 145, "The Sensibility of the Alimentary Canal" Oxford, 1911
- JORDAN, A C., *Chronic Intestinal Stasis*, Oxford, 1926
- KANTOR, J L., *J Amer Med Ass.*, 1934, CIII, 2016, *Amer J Roentgenol.*, 1923 XII, 444
- KRITHI, A., *J Anat Physiol.*, 1903, XXXVIII, 7
- KIRKET, P., "Recent Advances in Radiology", London, 1926
- KIRKLIN, B R., *Proc R Soc Med.*, 1934, XXVIII, 519
- KNOTHE, W., "Die Dickdarm schleimhaut", Leipzig 1932
- LUND, W F., and GLOOS, R E., *Arch Surg.*, 1934, XXIX, 365

- LARDEVOIS, G., *Bull Soc Med Hop. Paris*, 1911, LXXXVI, 96
LOCKHART MUMMERY, J. P., "Diseases of the Rectum and Colon," London, 1934
LOCKHART MUMMERY, J. P., and HODGSON, H. GRAHAM, *Brit Med J*, 1931, I, 523
LOCKWOOD, C. B., *Brit Med J*, 1882, II, 574
MAINCOT, G., SARASIN, R., and DUCLOS, H., "Exploration radiologique des colons et de l'appendice au moyen des solutions flocculantes," Paris, 1935
PATEY, D. H., and AECROFT, P. B., *Brit Med J*, 1935, II, 1197
QUERNEAU, J., *Mem Acad Chir.*, 1936 LVII 369
ROSS, J. PATERSON, and TELFORD, E. D., *Brit J Surg*, 1935, XXIII, 433
SNELL, A. M., and CAMP, J. D., *Arch Intern Med*, 1934, LIII, 615
SPRIGGS, F. L., *Brit Med J*, 1929, II, 569
SPRIGGS, E. L., and MARXER, O. A., *Quart J Med*, 1925, XIX, 1, *Brit Med J*, 1937, II, 987
STEPHENSON, F. B., *Radiology*, 1936, XVII, 49
STIERLIN, E., "Klinische Rontgendiagnostik des Verdauungskanals," Berlin, 1928
THAYSEN, T. E. H., *Lancet*, 1929, I, 1086

PART TWO .
BILIARY TRACT
BY
PETER KERLEY, M.D., F.R.C.P., D.M.R.E.

PART TWO
BILIARY TRACT
CHAPTER XXVI
ANATOMY AND PHYSIOLOGY

THE SYMPTOMATOLOGY of biliary disease is complicated and often misleading. Constitutional or local symptoms may predominate, and not infrequently the local symptoms are referred to a healthy viscera far removed from the biliary tract.

The introduction of cholecystography has thrown considerable light on the aetiology, course and symptomatology of biliary disease, but there is still much to be learnt and radiology is a most hopeful line of approach to outstanding problems. A detailed knowledge of the anatomy and physiology of the biliary tract is essential if we are to carry out a radiological examination thoroughly and assess our findings accurately.

ANATOMY OF THE EXTRAHEPATIC BILIARY TRACT

The normal gall bladder varies in shape, size and position according to the habits of the individual. It also varies according to the stage of filling or contraction in which it is visualised and it alters considerably in position with changes in posture. Roughly speaking we define three normal types—the spheroidal or hypersthenic type, the ovoid or sthenic type, and the elongated or hyposthenic type. The ovoid or sthenic is the type most often seen.

The normal gall bladder is composed of four parts viz a fundus, a body, an infundibulum and a neck. Smooth muscle fibres are found in the wall of the fundus and infundibulum but are almost completely absent in the body. Conversely there is much elastic tissue

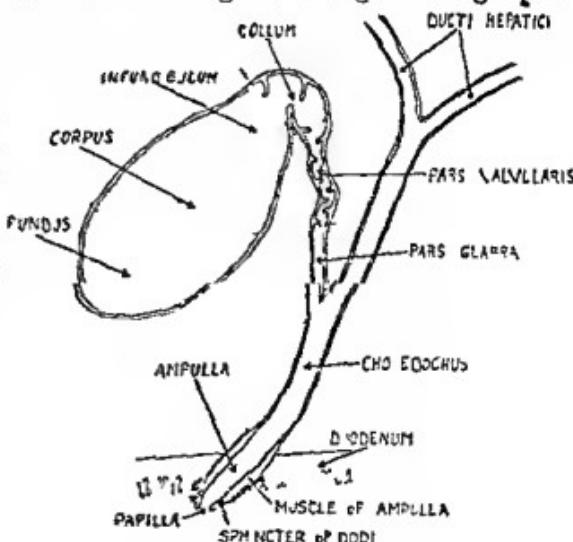


FIG. 219.—The extrahepatic biliary tract (By courtesy of G. Neumayer)

tissue in the body and relatively little in the fundus and infundibulum. The muscle fibres are arranged longitudinally and obliquely, but tend to be circular in the infundibulum. This circular arrangement of the fibres is continued into the neck and valvular part of the cystic duct and there is strong radiological evidence in favour of a sphincter between the infundibulum and the neck.

The neck of the gall bladder may lie in the same axis as the fundus but more often it turns inwards and downwards at a fairly sharp angle. The cystic duct usually arises at an angle from the neck but this angle varies considerably according to the type of gall bladder and the stage of its contraction. The proximal half of the cystic duct contains circular muscle fibres and the interior is thrown into folds known as Heister's valves. The distal half of the cystic duct is similar to the hepatic and common bile ducts in that it contains few muscle fibres if any, and is simply a fibro-elastic tube. The common bile-duct runs downwards parallel to the spine, and usually passes through the pancreas before entering the duodenum obliquely at the papilla of Vater. The volume of the normal gall bladder is about 30 c.c. but no limits can be fixed for its length and width.

RADIOLOGICAL APPEARANCES OF THE VISUALISED GALL-BLADDER

The Ovoid or Sthenic Gall-bladder

(A) THE PROXE POSITION.—(The appearance of the contracting gall bladder and bile ducts as described below can be noted only if the technique of serial radiographs immediately after a fatty meal is followed. By the ordinary haphazard technique the ducts are rarely visualised.) The gall bladder is ovoid or pear shaped about 9 to 10 cm long and about 3 to 4 cm wide. Its long axis is parallel to the spine and at right angles to the eleventh and twelfth ribs. The liver margin seen as an oblique line running downwards and outwards usually cuts across the gall bladder shadow at the level of the body. This corresponds with the usual anatomical description the fundus of the gall bladder being free and completely surrounded by peritoneum and the body, infundibulum and neck being fixed in the hepatic fossa by connective tissue. The gall bladder lies well forward of the kidney but radiologically the two shadows are superimposed. In most cases the gall bladder is superimposed on the upper pole of the kidney but it may be superimposed on the renal pelvis or it may lie medial or peripheral to the kidney shadow. Anatomically of course there is no relationship between the gall bladder and the right kidney, and the position and range of movement of both organs may vary considerably in the one individual. The radiological relationship is intimate and of much importance because of the possibility of the shadows of biliary calculi being superimposed on the renal shadow and vice versa.

If a barium meal is given it will be found that the fundus of the gall bladder is usually in apposition with the duodenal cap which is lying immediately

behind the fundus. In some cases the gall bladder lies well to the right of the duodenal cap and in other cases it lies to the left of the cap and may be in contact with the pyloric part of the stomach.

In about 20 per cent of normal individuals part of the gall bladder shadow is superimposed on the shadow of the second and third lumbar vertebra.

(B) THE ERECT POSITION -- Both liver and gall bladder are about 1 to 1 inch lower and lie below the shadow of the twelfth rib. Their relative relationship is unaltered but if the gall bladder has been lying partly over the spine in the prone position it tends to fall away from it in the erect position. In the erect position also the gall bladder shadow lies more to the right of the renal shadow. The relationship with the duodenum is unaltered.

(C) IN THE SUPINE POSITION the liver and gall bladder fall back and upwards. The long axis of the gall bladder becomes oblique instead of perpendicular and the fundus may lie completely behind the lower liver margin. The gall bladder lies well away from the spine and its shadow is above or barely touches the shadow of the upper pole of the right kidney. The gall bladder duodenal relationship is not altered. In the supine position the pear shape is lost and the upper part of the gall bladder the infundibulum is rounded and almost as wide as the fundus. Occasionally in this position a slight or deep indentation may be seen in the medial wall of the gall bladder. This indentation represents the point of division between the body and infundibulum and it should not be mistaken for spasm.

The neck of the gall bladder the cystic duct and the common bile-duct can be visualized only during the phase of active movement following a fatty meal. In most cases a sharp indentation on either side separates the neck from the



FIG. 9 The normal oval gallbladder as seen in the prone position

infundibulum and at certain stages the neck may appear to be completely separate from the infundibulum thus is fairly conclusive evidence that there is a strong sphincter between the neck and the infundibulum. The neck itself may be shaped like the pointed end of a pencil and run straight upwards but more often it curves inwards and has been aptly described as resembling a bird's beak.

The cystic duct usually leaves the neck to curve gently upwards and inwards for about $\frac{1}{2}$ to 1 inch it then forms a complete semicircle and joins the common bile duct but the point of junction cannot be visualised. Occasionally the cystic duct leaves the neck at right angles and in some cases the neck is so bent over on the infundibulum that the cystic duct appears to be leaving the infundibulum at right angles. This appearance is very unusual but should not be mistaken for pathology (adhesions). The proximal half of the cystic duct containing muscle fibres and Heister's valves has a curious appearance due to the mixture of bile and mucus. Small round globules of concentrated bile appear to be lying between the mucosal folds and this results in a rosary bend appearance. This occurs in 70 per cent of cases and has occasionally been misinterpreted as stones in the cystic duct.

The distal half of the cystic duct and the common bile-duct are seen as a smooth narrow tube with no irregularities of outline at any part the shadow of the bile in these parts is only about half the density of the shadow in the gall bladder and in the muscular part of the cystic duct. The lower end of the common bile duct usually fuses away into the spinal shadow and its point of entry into the pancreas cannot be seen.

The Spheroidal or Hypersthenic Gall bladder

In stocky or short obese individuals and in most children the gall bladder tends to be more rounded and to be fixed more completely in the hepatic fossa. In some cases the whole of the gall bladder is actually embedded in hepatic tissue. It is then seen radiologically as a completely round opacity. It follows that the mobility of the hypersthenic gall bladder is limited and its range of movement is dependent on the range of movement of the liver which is slight. The hypersthenic gall bladder is situated relatively high and usually lies under the tenth or eleventh rib. It is situated well to the left of the spine and well above the right kidney shadow. Rarely as described by Vemours *Anjouste* a hypersthenic gall bladder is actually superimposed on the spinal shadow. In some cases the hypersthenic gall bladder has the ovoid shape of the sthenic type its long axis is then parallel to the lower margin of the liver and is almost at right angles to the shadow of the spine.

The neck and duets are more difficult to visualise in the hypersthenic type. The neck is only occasionally seen and may appear to be the most dependent part of the gall bladder. In most cases of this type there is no visible differentiation between the neck and infundibulum and the cystic duct seems to arise directly from the lowest part of the gall bladder.

FIG. 221.—A normal ovoid gall bladder during the phase of active contraction. The cystic and common ducts are clearly visible; note how the coiled cystic duct tends to unfold.



Fig. 112. A small hollow in the sandstone floor of the entrance of the
cave. The entrance is at the top of the photograph.



The Long or Hyposthenic Gall-bladder

This type occurs in tall slender individuals, and is characterised by a very wide range of movement. The fundus and body are completely free and covered by peritoneum and the neck and infundibulum are attached to the liver by lax connective tissue. In the prone and erect positions the gall bladder is seen to be parallel to the spine and in very many cases the whole of the shadow is superimposed on the spinal shadow and may thus be overlooked. The fundus of the gall bladder may be as low as the level of the fifth lumbar vertebra in the prone position and may be level with or lower than the lower pole of the right kidney. One gets the impression in these cases that the gall bladder is ptosed and inefficient. This is invariably an erroneous impression for if the examination is properly completed and the gall bladder observed in its active phase it will be found to contract and evacuate its contents normally. The position of the gall bladder has nothing at all to do with its tone and there is no reliable record of a pathological ptosis of the gall bladder. The neck and ducts are easily visualised in the hyposthenic gall bladder and are similar in position and appearance to those seen in the sthenic type. There are of course many intermediate types between the three just described and the above classification should be taken only as a rough guide.

THE FUNCTION OF THE GALL-BLADDER

The liver is constantly secreting a thin watery bile which flows into the bile ducts and in the ducts is diluted by the addition of mucus. This bile enters the gall bladder by flowing up the cystic duct provided the sphincter of Oddi is closed (*Aeueman*). The gall bladder concentrates this bile and when the pressure in the gall bladder falls below that in the bile ducts more watery bile runs in. This process continues until the gall bladder is full of concentrated bile. According to *Aeueman* the sphincter of Oddi then relaxes and liver bile drips steadily into the duodenum.

The concentration of the bile in the gall bladder is carried out chiefly by



FIG. 3 The normal spherical or hypersthenic gall bladder

absorption of water. Bilirubin is concentrated about twenty times, and cholesterol, bile salts, and calcium about five to ten times. Calcium is excreted into the bile by the liver and partly absorbed and partly concentrated by the gall-bladder. It is now generally agreed that the gall bladder does not secrete cholesterol.

This process of concentration can, to a certain extent, be confirmed and studied by cholecystography. An hour or two after injection of sodium tetrachlorophenolphthalein, a faint gall bladder shadow can be seen, from two to six hours after the injection the intensity of the shadow increases, but the size of the gall bladder diminishes. It follows, from these observations that at different times the gall bladder contains bile of different specific gravities, one layer, so to speak, floating on top of another. This theory explains the increased density of the shadow when the gall bladder has partially evacuated its contents after a fatty meal. During the evacuation the bile of low specific gravity and gall bladder mucus are expelled first and the bile of highest specific gravity remains behind. Whether the theory of multiple layers of bile and mucus is correct or not, particular attention should be paid to the question of different densities in the one gall bladder. There are an increasing number of reports of floating gall stones i.e. small stones floating on top of concentrated bile, and it seems likely that with routine hospital technique these stones are being overlooked and the gall bladders passed as normal.

The Mechanism of Emptying of the Gall-bladder

There is still considerable disagreement as to the exact method by which the bile leaves the gall bladder, and it has even been suggested that the bile was reabsorbed in the gall bladder and that Heister's valves were Nature's device to prevent the bile flowing back from the gall bladder into the cystic duct.

It has been clearly established by Westphal and others that the vagus is the motor nerve of the gall bladder—light vagus stimulation causing the gall bladder to contract and the sphincter of Oddi to relax with simultaneous peristalsis of the ampulla and a flow of bile into the duodenum. Strong vagus stimulation causes spasm of the gall bladder and ampulla and cessation of flow. Sympathetic stimulation causes the gall bladder and ampulla to relax, with simultaneous contraction of the sphincter of Oddi and no flow. As Newman points out, there is obviously a reciprocal innervation. There is a humoral mechanism in addition to the nervous mechanism, the normal gall bladder reacting at once to injections of cholecystokinin, a substance which is produced by the action of acid on the mucosa of the duodenum and jejunum. There is probably some cholecystokinin formed also in the stomach.

The normal physiological stimulus to the evacuation of the contents of the gall bladder is the presence of fat in the stomach and duodenum. There is a slight psychic reflex, taste and smell causing the gall bladder to alter its resting position and adopt what we shall refer to as the "preparatory position." Taste and smell, however, will not cause the gall bladder to contract. Nemours-

Auguste has shown that this 'bucco vesical reflex' can be stimulated repeatedly without any evacuation of the biliary contents. The same author has shown by mixing his fats with barium that the gall bladder in many normal cases begins to evacuate before the pylorus has opened i.e. before any fat has touched the duodenal walls.

In studying the gall bladder radiologically we should see it in three phases:

(1) *The resting phase* with the gall bladder flaccid and concentrated bile in the fundus and body.

(2) *The preparatory phase* which can be excited by smell or taste or observed immediately after ingestion of the fatty meal. In this phase the gall bladder, so to speak, pulls itself together. It alters its shape so that concentrated bile appears to be evenly distributed in the whole of it and the infundibulum and neck are visible. It alters its position at the same time the general tendency being to move upwards and outwards. The range of movement of the gall bladder in the preparatory phase varies of course with the type of gall bladder. In the hyposthenic gall bladder a considerable shift takes place while in the hypersthenic type little or no alteration in position occurs.

(3) *The phase of contraction* is observed after ingestion of a fatty meal at intervals varying in the normal from five to thirty minutes. In the contraction phase the gall bladder is in the same position as the preparatory phase but its volume is smaller and concentrated bile is visible in the cystic and common ducts. The normal times for complete evacuation of the gall bladder have not yet been established. *Boyden* has shown that the gall bladder empties more rapidly in women than in men and it is probable that there is quicker evacuation in children than in adults.

There is no doubt whatever that the gall bladder empties its contents by muscular contraction although the nature of these contractions must be totally different from those which occur in the gastro intestinal tract. True peristalsis has never been observed and there are only one or two records of a wavy outline of the gall bladder in any way suggestive of peristalsis. It is possible that an overdistended gall bladder may empty by elastic recoil but serial radiograms of the normal gall bladder during the contraction phase do not suggest that elastic recoil plays any part in the average case. In some normal cases the gall bladder certainly rotates from side to side the author having observed the neck first pointing to the periphery and later pointing to the spine. Both the neck and the cystic duct tend to straighten themselves out as the bile is forced into them. It has been proved that the normal gall bladder cannot be emptied by voluntary movements respiration nor duodenal peristalsis. Radiological observations have also shown that vomiting does not cause it to contract. In two patients one with hyperthyroidism and one with hypertension the author observed the gall bladder contracting under pressure from a compressor but although there was no organic biliary disease in either patient, their general nervous instability was such that none of their viscera could be considered perfectly normal.

CHAPTER XXVII

TECHNIQUE FOR X-RAY EXAMINATION OF THE BILIARY TRACT

PRELIMINARY PREPARATION

THE PATIENT must be adequately prepared by suitable aperients or enemas. Liquids and gas in the intestines can obscure the gall bladder completely or produce shadows simulating gall stones. Drastic aperients such as castor oil and magnesium sulphate cannot be recommended as their action may irritate both the gastro intestinal and biliary tracts for some days. Cascara is very suitable as its action is mild and it does not tend to excite gas formation. In patients with obstinate constipation an enema is necessary and this should be given at least 24 hours before the X-ray examination. Persistent gas formation despite the effect of aperients and enemas may cause great difficulty both in technique and interpretation. Many drugs have been used in an effort to expel intestinal gas and the most effective of these is a substance known as pitressin. This substance is administered subcutaneously 0.5 c.c. being injected from one to two hours before the X-ray examination. The dose can be repeated without any harmful effects in half an hour. Pitressin is eminently suitable in difficult gall bladder cases as it does not cause the gall bladder to contract.

ROUTINE OF EXAMINATION

In all cases a preliminary radiogram on a 15×12 film should be made. This film taken in the prone position should include the domes of the dia phragm and the crests of the ilii. It should show the lower liver margin, the kidney shadows and the edge of the psoas muscles. A Potter Bucky dia phragm is essential to ensure good detail and the finer the grid the better the results. The Ljshom stationary grid is not very suitable because the grid lines may obscure important detail. The most important feature in the technique is speed, and everything else should be subordinated to this. The slightest respiratory movement may be sufficient to cause enough blurring to conceal gall stones. The patient should be made as comfortable as possible and the exposure made at the end of expiration. An ideal speed and one well within the limits of most modern apparatus is two fifths to one half a second. The author uses this speed with the following factors 90 Ma 75-80 KV 90 cms tube film distance. Synchronised moving grid.

If the preliminary radiogram shows indisputable evidence of gall stones it may not be necessary to carry the examination farther but generally speaking it is a wise procedure to make a thorough examination by cholecystography.

ns this may reveal unsuspected pathology in the ducts. When the gall bladder has been made visible by sodium tetrachlorophenolphthalein films are taken with the technique described above. In a fair percentage of cases the first picture will show some part of the shadow overlapping the spinal shadow. Using a ball of cotton wool as a compressor it is easy to displace the gall bladder away from the spine—this manœuvre will not cause the gall bladder to contract and the shadow can be adequately studied on this second picture. A third picture should be taken in the erect position with light compression. With modern methods of cholecystography and a good fluoroscopic screen it is not difficult to visualise the gall bladder on the screen when it has already been located on the prone pictures. Only light compression should be applied as the object of this method is to reveal floating stones and strong compression may force such stones into the concentrated bile at the fundus. When these pictures have been taken the patient is given a fatty meal consisting of two or three eggs beaten up with milk. Gutmann and Nemours Auguste add some barium sulphate to this meal and simultaneously with the gall bladder study the gastric and duodenal mucosa. A picture is taken in the prone position immediately this meal is ingested and usually shows the gall bladder to have changed from the resting to the preparatory phase. Five to ten minutes after ingestion of the meal two further pictures are taken in the prone position one central and one slightly oblique with the right side of the body rotated about 15 to 20 degrees away from the table i.e. to the left. The cotton wool compressor is used for these and it is also helpful to tilt the patient head downwards about 10 to 15 degrees. In 80 per cent of cases the cystic and common ducts will be visible on these pictures. If not similar pictures are taken twenty and thirty minutes after the fatty meal until the ducts have been visualised. Subsequent pictures are taken an hour after the fatty meal and these usually show the gall bladder to be contracted to one third or one fourth of its original size.

This technique may seem too elaborate and expensive but it is the only one by which the biliary tract can be thoroughly investigated and as will be shown later it throws much light on those obscure cases of biliary dyskinesia where there is an apparently normal gall bladder shadow associated with classical clinical symptoms of gall bladder distension.

CHOLECYSTOGRAPHY

It was long known by physiologists that the halogens were excreted almost entirely by the liver in the bile and tetrachlorophenolphthalein was frequently used as a test of liver function. Graham and Cole in 1924 applied this knowledge to radiology, and attempted to visualise the gall bladder in vivo by substituting the heavier bromine molecule for the chlorine one. Their results were successful and in a very short period the still heavier iodine molecule was substituted for the bromine—the iodine compound giving a better shadow with

a smaller dose. The substance in common use to day is the acid sodium salt of tetraiodophenolphthalein. It deteriorates rapidly on exposure to light and should be kept in opaque bottles. The drug should be freshly prepared for intravenous injection. The drug can be administered intravenously or orally, and although most workers now employ the oral method as being simpler and less dangerous than the intravenous method there are many cases in which the intravenous method is preferable. If an intravenous injection was an absolutely harmless procedure it would obviously be the method of choice as a measured quantity of dye is injected into the blood-stream and it can be excreted only through the biliary tract. Using the oral method there is always the possibility that the dye will be unabsorbed in the intestine or that the phenolphthalein will excite diarrhoea with rapid excretion of much of the iodine through the bowel. There is a group of cases in which the concentration of dye in the gall bladder is poor and only a faint radiological shadow is obtained. The interpretation of faint shadows is much more reliable with the intravenous than with the oral method.

Technique for the Intravenous Method

The patient on the evening before the injection has a liberal dinner, including fats. The injection is given early the following morning weak tea with sugar but without milk being allowed for breakfast. The dye which should be prepared the evening before is warmed to body temperature and injected slowly. Some workers inject $\frac{1}{2}$ c.c. of 1 in 1 000 adrenalin subcutaneously before the intravenous injection but this is unnecessary and indeed in some cases may produce unpleasant sensations of nausea and fainting. The syringes used for the dye should be thoroughly cleaned in sterile water particular care being taken that there is no oily or greasy substance on the walls. For an average individual 4 grms of sodium tetraiodophenolphthalein dissolved in 40 c.c. of distilled water are used. For thin individuals and children half this quantity is used. As the dye is blue black in colour it is almost impossible to see blood flow back into the syringe and it is usually easier to place the needle in the vein and then attach the syringe when the needle is safely in position. The dye should be injected very slowly a safe rate being 4 c.c. per minute. There should be no pain during the injection and the patient should be kept under observation for half an hour afterwards. After this period he can carry on with his usual work. The first picture is taken four hours and the second picture eight hours after the injection. The maximum concentration is usually at eight hours and at this time the examination is completed by observing the effects of the fatty meal.

Contraindications to the intravenous method are advanced cardiac and pulmonary disease, asthenia or cachexia and severe jaundice. The dangers of intravenous cholecystography are greatly exaggerated. Fried and Whitaker have shown experimentally that the liver may be more than half fatty

degenerated and yet excrete the dye normally without any trouble Accidents following the injection may be due to one of three causes (1) An impure solution has been used (2) An excessive dose has been injected There have been two fatal accidents following injection of 50 grms and one following the ingestion of 5 grms In these three cases however autopsy showed extensive liver disease (3) The dye has been injected too quickly Too rapid injection is much the commonest cause of accidents In some people a curious and unexplained train of symptoms follows the rapid injection into the blood stream of any substance of high atomic weight Half to one hour after injection the patient complains of cold and shivering and there is marked trembling of the limbs In severe cases there is pain behind the eyes and pains in the bones Vomiting and fainting can also occur and in very bad cases the patient may collapse into a kind of coma Many workers have shown that there is a rapid fall in blood pressure immediately after the injection this might cause collapse in a patient with heart disease but is unlikely to be responsible for the symptoms of pain and trembling of the limbs Zappala has shown that following injection of tetraiodophenolphthalein there is a hypoglycaemia after half an hour a hyperglycaemia after two hours and then a gradual return to the normal values in six hours Hypoglycaemia is a very likely cause of the symptoms just described and many workers use glucose along with the dye to prevent the onset of such symptoms In most cases the injection of 1 c.c. of adrenalin gives prompt relief but provided that the injection is given slowly there is no need to use either glucose or adrenalin as a preliminary prophylactic

There appears to be a general impression that leakage of the dye from the vein into the soft tissues is a serious incident This is not so and I have observed many cases where such leakage had occurred and no untoward effects other than temporary stiffness of the arm ensued Of course infection is always liable to occur if the dye or the instruments have not been sterilised In rare cases a severe non bacterial cellulitis or a mild phlebitis may occur

Rapid Cholecystography

Many workers have attempted to combine the sodium tetraiodophenol phthalein with some other substances which is rapidly excreted through the liver thereby obtaining more rapid visualisation of the gall bladder The method which has attained most prominence is that described by Antonucci It was early recognised that during either oral or intravenous cholecystography in diabetes the shadow of the gall bladder appeared much sooner than in normal individuals Antonucci's technique is based on this observation The patient has a diet poor in carbohydrates for three or four days before the injection The injection is made fasting under the conditions already described Ten minutes before the injection of the opaque salt 12.5 c.c. of a 40 per cent solution of glucose are injected Ten minutes after the injection of the opaque salt 2 units of insulin are injected The gall bladder can be faintly seen half

an hour later and the maximum concentration is obtained about two hours later. The contractions of the gall bladder and the visualisation of the ducts are then obtained by the usual fatty meal. The physiological basis of this technique is not properly understood. It is thought that the tetraiodophenol phthalein is combined in some manner with the glucose and that the combination is more readily excreted through the liver than the opaque salt by itself. It may be however that in hyperglycemia the liver is stimulated and more rapidly eliminates the opaque salt. The gall bladder filled by this rapid method is larger than the gall bladder filled by the usual method and moreover the concentration with *Antonucci's* technique is not very good. It is doubtful if any material advantage is gained by *Antonucci's* technique and certainly none which outweighs the disadvantages of injecting three different substances at very short intervals.

The Oral Methods of Cholecystography

If sodium tetraiodophenolphthalein is ingested in a pure form nausea and vomiting usually follow in a short period of time. This is due to the salt mixing with the gastric secretion and forming phthalic acid which is a distinct gastric irritant. In the early days of oral cholecystography the salt was usually administered in gelatine or keratin capsules which it was hoped would not be digested until they had left the stomach. In many cases however the capsules were not dissolved at all and were excreted intact with the feces. The manufacturers have largely overcome this difficulty and the dye is now made up in a fairly palatable form with the phthalic acid already precipitated. About 25 per cent of patients complain of nausea after ingestion of the dye and of these about 5 per cent actually vomit. If the vomiting occurs within one hour of ingestion the test is invalid as too much of the dye is lost. If the vomiting occurs within two hours of ingestion the test is usually valid as in this time sufficient dye has passed over the pylorus to be absorbed in the small intestine. Some workers give various sedative drugs such as Dover's powder to prevent vomiting but the administration of such substances is to be deprecated. In the present state of our knowledge of the physiology of the biliary tract it is impossible to predict the effect of many such drugs. They may cause delay in filling or emptying or poor concentration.

Single dose Oral Cholecystography

The following simple preparation is the only one necessary and is successful in the vast majority of cases. Two days before the examination the patient takes a mild aperient enema for preference. The day before the examination the patient has a meal containing fats and eggs for lunch and for dinner at 7 p.m. has a fat free meal. Many English workers do not consider complete fat restriction essential. For dinner dry toast, baked potatoes, vegetable soups and all forms of fruit are allowed. Fruit drinks and black tea or coffee are

also permissible. Butter eggs milk cream fish meat and salad dressings are not allowed. At 9 p.m. 4 grms of the opaque salt are mixed with half a tumbler of water and swallowed in one draught. Water may be taken freely after this and I have found alkaline waters such as Vichy and Vittel very effective in reducing the degree of nausea and the possibility of vomiting.

The patient may have weak black tea or coffee on the morning of the examination but no solids. The X-ray examination is carried out at 11 a.m. i.e. 14 hours after ingestion of the dye. If there is no shadow or only a faint shadow visible at this period a soft picture of the abdomen is taken to see if there is much unabsorbed dye in the intestines. If there is a further 4 grms of dye are given to the patient to be taken with a fat free lunch. A fat free dinner is allowed and he returns fasting the following morning.

Intensive Oral Cholecystography

There are many variations of the intensive or double dose oral method. In most people the single administration of 4 grms in one dose gives a good concentration and this method has the great advantage of simplicity. Many workers follow modifications of a technique devised by Stewart and Illick and give small quantities of the dye over a period of two or three days during which period the patient must be on a completely fat free diet. This is a complicated procedure and unsuitable in many patients whose ideas of fats and non fats are peculiar. Recently Whitaker has shown that the gall bladder is completely full of concentrated bile in 24 hours and therefore there is no point in administering the dye over a longer period than this as it does not add to the concentration.

The author's technique is simple for the patient and usually gives a sufficiently good concentration for the gall bladder to be visualised on the screen with a compressor. The day before the examination the patient has a normal lunch not fat free and immediately after this meal takes 2 grms of the dye. At 7 p.m. the patient has a fat free dinner and takes 4 grms of the dye an hour after this. During the evening a bottle of alkaline water is drunk and the patient presents himself for the examination between 10 and 11 a.m. the following morning. If the first pictures in the prone position show a good shadow one further picture is taken in the erect position. A meal of three eggs in milk and a teaspoonful of sherry is given and further pictures taken 5, 10 and 30 minutes after ingestion of this fatty meal. The complete examination takes about an hour. In some cases the gall bladder contracts very slowly and an hour and a half to three hours may be required to obtain all the necessary data.

CHAPTER XXVIII

THE PATHOLOGICAL BILIARY TRACT

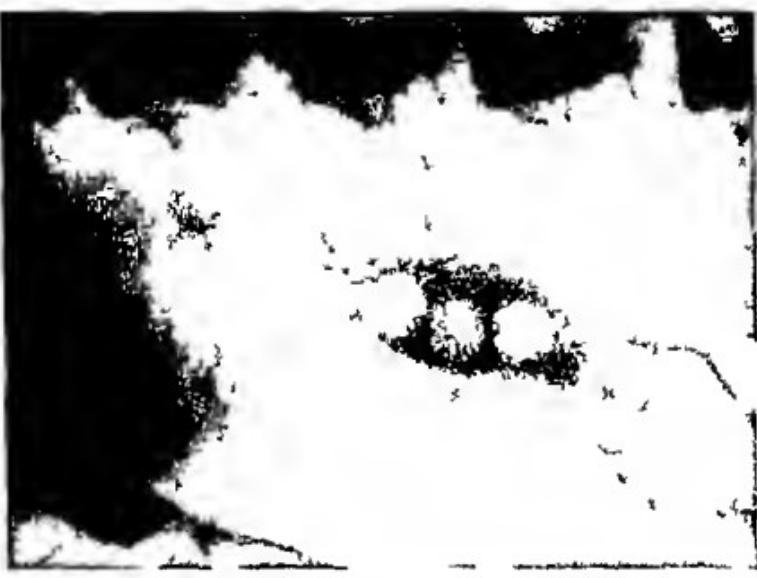
CONGENITAL MALFORMATIONS

A STUDY of comparative anatomy reveals extreme developmental variations of the biliary tract in animals. Thus the horse and the rat have no gall bladder while the cow and the mouse have. The pigeon is the only bird without a gall bladder but it has one during foetal life. One would expect to find the human biliary tract showing many developmental abnormalities but this does not appear to be the case. *Boyden* in 19 000 autopsies found five cases of double gall bladder with a single cystic duct. His reports of double gall bladder are very rare. *Braunschweig* has described such a case, with the shadows of the two gall bladders superimposed in the postero anterior view. One concentrated the dye much better than the other. Oblique views after a fatty meal showed the two gall bladders contracting well and lying well clear of each other. The ducts were not very clearly visible but his pictures suggest that there was a separate cystic duct for each vesicle. A bifid gall bladder is also known, a longitudinal septum dividing the gall bladder into two separate sections. *Hartung* has demonstrated radiologically a very unusual anomaly, the gall bladder attached to the left lobe of the liver. *Hartung's* pictures show a normal gall bladder lying on the left side of the spinal shadow parallel to the lesser curvature of the stomach. Complete absence of the gall bladder has also been described in man; this defect is usually but not always accompanied by gross dilatation of the common duct.

The most frequent congenital anomaly seen on radiograms is a septum extending across the fundus. This septum may be minute or it may almost divide the fundus into two separate chambers. In the average case there is a deep indentation on the fundus rather similar to an incisura on the greater curvature of the stomach and the gall bladder assumes a shape aptly described as resembling a Phrygian cap. This deformity is probably of no clinical significance although some workers believe it may predispose to gall-stone formation.

Flint has described various deformities of the bile ducts and of the right hepatic cystic and gastro duodenal arteries. There may for example be a double cystic duct and a single common duct or there may be a single cystic duct and two common ducts. The implantation of the cystic duct into the common duct may also take an abnormal course. Few of these abnormalities have been detected radiologically probably because the function of the gall-bladder and the visualisation of the ducts have not been investigated as a

Fig. 2.—II is probably a case of lumbal or lili-
gait. It has no local contur in the stones. This is
similar to Brans J. Eng's (see p. 30). No ol. rifice
confirmation.



III.—Dolos, Hillitter—In these cases one can
see the normal





FIG. 226.—A characteristic example of the Ihering cap formity. No clinical symptoms.

bound to be failure to concentrate it. A plain radiogram of the gall bladder region may be helpful by revealing opaque calculi.

Chronic cholecystitis may follow the acute form or the disease may be chronic from the first. It may be part of chronic catarrh of the ducts and it may or may not be associated with gall stones. The chronically inflamed gall bladder is usually distended with mucus, its walls are thickened and its mucosa is thrown into heavy folds. Rarely the gall bladder becomes shrivelled up and small (*cholecystitis obliterans*). In cases where the cystic duct is blocked by a stone the gall bladder becomes permanently distended, its walls atrophy and eventually become a thin sheet of fibrous tissue like parchment. The visibility of the dye in the gall bladder is entirely dependent on the power of the gall bladder to concentrate it. If therefore we find complete absence of a shadow after proper technique the dye has either not reached the gall bladder because of obstruction of the cystic duct or the dye has reached the gall bladder but the mucosa is so extensively damaged that it cannot concentrate it. In either case the gall bladder is a surgical one. It has been suggested that non visualisation occurs in the later stages of pregnancy due to pressure; recent work has not substantiated this suggestion. Not much is known about the effect of extensive liver disease on the concentration of bile in the gall bladder. Whitaker found in dogs with extensive liver damage a normal concentration of the dye in the gall bladder but clinical experience does not

routine. With modern technique, however, it is to be expected that more radiological reports of these anomalies will be described in the near future. A rare congenital abnormality is obliteration of the bile ducts. Such cases of *icterus neonatorum* do not live very long and obviously the abnormality can not be detected by cholecystography.

CHOLECYSTITIS

Cholecystitis may be acute or chronic. There are many varieties and degrees of intensity.

The acute type may be catarrhal, suppurative, ulcerative, phlegmonous or gangrenous but irrespective of the type cholecystography is contraindicated in all acute cases. The dye may aggravate the inflammation and in any case there is

A plain radiogram of the gall bladder

altogether support this idea. The effect of any acute abdominal condition on the mechanics of the biliary system is impossible to estimate, but the consideration is of no importance, as cholecystography is contraindicated in such cases. It can be stated without reservation that complete non visualisation indicates a gross lesion of the biliary tract and is an indication for surgery.

Mild Chronic Cholecystitis—We must discuss now these cases of mild cholecystitis which constitute the greatest radiological problem. The so-called lipid cholecystitis (strawberry gall bladder—cholesterosis) is extremely common. MacCarty found 936 cases of this disease in 3,000 excised gall bladders. Rolleston and McNee summarise the pathology as follows: "From lymphatic obstruction the villi become loaded with cholesterol absorbed from the gall bladder bile. Externally the gall bladder is normal except for an enlarged gland near the cystic duct, internally the papille appear as yellow streaks from contained cholesterol-ester, and so resemble strawberry seeds; they break off, and so may form the nucleus of future calculi." Newman does not consider the condition worthy to be elevated to the position of a disease although Moynihan once described it as a "disorder of the gall-bladder requiring cholecystectomy." Newman's opinion would appear to be that the condition is a mild inflammatory process consequent upon a mild infection of the gall bladder, but that possibly it may be due to metabolic or dyskinetic causes. The evidence in favour of the latter causes is so far inadequate.

Radiologically therefore we are faced with a condition which we know to be common and which, even when trivial, must be associated with some disturbance of the biliary function. In a cholecystographic examination we see three points by which we can estimate the biliary function: (1) the rate of filling of the gall bladder, (2) the capability of the gall bladder mucosa to concentrate the bile as evidenced by the intensity of the shadow, (3) the rate of emptying of the gall bladder.

(1) **THE RATE OF FILLING OF THE GALL BLADDER**—It is obvious that the rate of filling, i.e. the rate of appearance of a shadow, can never be estimated accurately by the oral method and indeed this is a strong argument in favour of using the intravenous method in the "doubtful" cases. Following a properly administered intravenous injection of the dye, a faint but obvious shadow should be seen four hours later, and the shadow increases in intensity for another four hours. This average rate of appearance of the shadow has been proved, and if we add as a liberal margin another two hours as being within the normal limits we can state that if there is no shadow visible after six hours there is disturbance of the function of the liver or gall bladder or both. Bearing in mind that experiments on animals with artificially damaged livers do not show much delay in the rate of appearance of the shadow, and that in most cases which we examine it is safe to assume that there is no gross liver

disease it follows that delay in the rate of filling is due to disturbance of the gall bladder itself. In view however of *Cullinan's* work on the frequency of sub acute necrosis of the liver the possibility of the liver being at fault should not be entirely excluded.

(2) THE INTENSITY OF THE SHADOW.—Unfortunately we have no standard criterion by which we can measure the intensity of the shadow. Some workers compare the shadow of the gall bladder with the shadow of a transverse process and others use the kidney or liver shadows as a standard. These criteria are too unreliable for general purposes and the estimation of the intensity of the shadow must always be a personal one. There can be no possible doubt of a very faint shadow—it means either that the gall bladder is full of mucus or that its mucosa is sufficiently damaged to prevent normal concentration. What one may term a poor shadow is one of the most difficult problems set to the radiologist. It is impossible to dogmatise on this question and perhaps the wisest course is not to diagnose pathology in these cases on the intensity of the shadow alone although statistics for the Mayo Clinic show that the poorly filling gall bladder is pathological in approximately 90 per cent of cases. There is conclusive evidence that a strawberry gall bladder may give a shadow of normal intensity.

(3) THE RATE OF EMPTIMENT OF THE GALL BLADDER.—There is a conflict of opinion on this question some workers believing that the strawberry gall bladder empties too quickly and others that it empties too slowly, the majority being of the latter opinion. We can only estimate the value of this sign if the examination is carried on until the gall bladder is completely emptied. It is not safe to assume that if the gall bladder contracts down to half its volume after a fatty meal the elasticity of its walls is intact. There are many cases in which the gall bladder makes one vigorous contraction after a fatty meal and then relapses into a condition of atony with stagnation of the residual bile for a long period. *Vernoux Auguste* who has investigated this problem very thoroughly thinks that in females the normal gall bladder should be completely emptied in an hour after a fatty meal and in males in an hour and a half. Any longer period he considers to be evidence of disturbance of the biliary function. The standards are rather severe and most workers would prefer a longer period say three hours. *Vernoux Auguste* also stresses the appearance of the dye in the gall bladder in the usual prone position. If there is concentrated dye only at the fundus and if the intensity of the shadow diminishes progressively from below upwards he considers there is some pathology present. This sign is of doubtful value as in a normal gall bladder there may be as much as 20 cc. of mucus secreted and floating on top of concentrated bile. In these mild cases of cholecystitis the clinical and X-ray findings must be carefully correlated. If a thorough examination has been made and the gall bladder fails slowly to empty slowly and gives a shadow of weak intensity it is safe to diagnose cholecystitis.

GALL-STONES

Gall stones are composed in varying proportions of cholesterol bile pigments and calcium salts. There are probably many factors essential for the formation of stones but the most important ones are infection and biliary stasis. Cholesterol is the dominant element in the majority of gall stones and thus is a substance non opaque to X rays. In many cases however there is either a central dense nucleus or bilirubin calcium is laid down in thin layers over the cholesterol. Direct visualisation of gall stones is dependent on the quantity of bile pigment and calcium salts present. In the pre cholecystography era skilful workers estimated that they could visualise about 40 per cent of gall stones but this proportion even with modern technique is much too high and 10 per cent would be a fair estimate. Stones composed almost entirely of cholesterol can sometimes be visualised as so called negative shadows but this diagnosis unsupported by cholecystography is never more than a possibility as there are so many possible causes of negative shadows in radiography of the right hypochondrium.



FIG. 227.—Laminated stones in the gall bladder and one in the cystic duct. Oral cholecystography shows poor concentration from associated chronic cholangitis.

Occasionally gall stones are seen which may be composed of about 90 per cent of calcium carbonate and 10 per cent of cholesterol. These stones are of two types white and green. The white ones are soft, and associated with obstruction of the cystic duct, the green ones contain copper in addition to calcium carbonate and are associated with some general metabolic disturbance.

Gall stones are usually multiple and vary in size from a grain of sand to a florin. The smaller the stones the greater the number present.

most common gall stone is the faceted stone. This is composed of a small round central nucleus surrounded by successive layers of cholesterol crystals. Layers of protein and bilirubin calcium are laid down here and there between the cholesterol and these render the stones radio-opaque. On a radiogram this type of stone is moderately opaque has a clear centre a dense periphery and a polygonal or faceted outline. When the gall bladder is packed with these stones it has a mottled appearance. Round stones are less common and tend to be larger. The round stone has a translucent centre and an outer



FIG. 298. Radiogram of gall stone with opaque nucleus and outer laminae.

layer of bilirubin calcium which appears as a white ring. The calcium may not surround the whole of the stone and only a fine semicircular or sickle shaped layer of calcium may be visible. The round stone varies much in size but is seldom smaller than a pea and may be as big as a florin. Multiple punctiform opacities the so called hole stone are not very frequent but are easy to diagnose as there is no other cause for opacities of this type in the right hypochondrium. Very rarely one sees a stone with a dense calcified nucleus and a non opaque cholesterol body the latter visible as a negative shadow round the dense nucleus. The calcium carbonate stones are rare. They are usually single and round or barrel shaped.

Differential Diagnosis — Gall stones may be confused with renal stones calcified glands calcified costal cartilages intrahepatic calcifications

Renal stones and gall stones are not infrequently present together. As a rule renal stones are denser larger and more irregular in outline than gall stones but occasionally gall stones very similar to renal stones occur. The differential diagnosis can be made directly by taking pictures at different phases of respiration and in different postures. The gall bladder has a wider range of movement during respiration than the kidney. In the prone position a gall stone may be superimposed immediately over the renal pelvis but if the patient turns about 30 degrees to the left i.e. with the right side of the body tilted upwards and the left side in contact with the Potter Bucky the renal

and gall bladder shadows are separated and a biliary opacity is projected in front of the kidney. In the true lateral position a gall stone is seen anterior to the spine and a renal stone is superimposed on the spine. In the supine position a gall stone moves upwards and outwards while a renal stone maintains its position relative to the spinal column. Rarely renal stones lying in a large hydro or pyo nephrotic sac can be differentiated from gall stones only by carrying out a pyelography or cholecystography.

Calcified glands in the abdomen are presumed to be of tuberculous origin. Tuberculosis of the glands in the porta hepatitis is almost unknown and generally speaking it is unusual to find calcified glands in the right hypochondrium. Most abdominal calcified glands are in the mesentery and have a considerable range of movement. The demonstration of this wide range of movement by compression is often a simple and effective method of diagnosis. The calcification in glands is very often granular a form of calcification not seen in gall stones. In doubtful cases a cholecystography solves the problem.

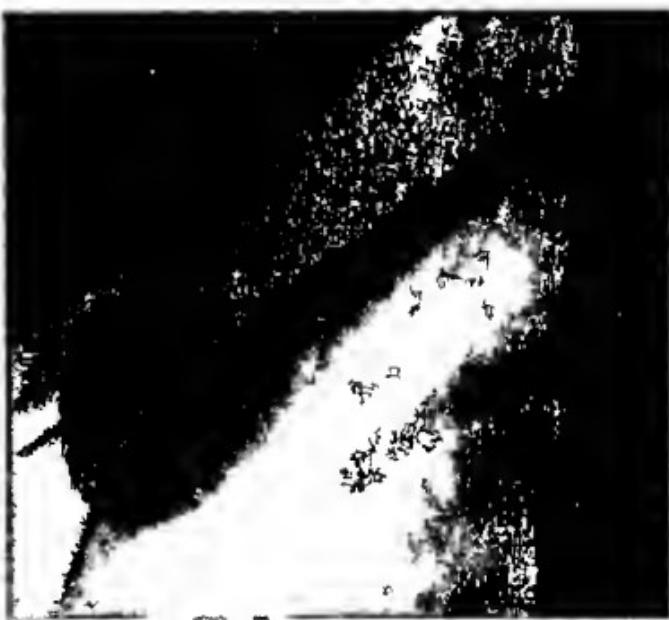


FIG. 9.—Free transparent (cholesterol) gall stones shown by oral cholecystography.

Calcified costal cartilages vary enormously in shape and size. Rouden has shown that they are often convex downwards and thus they may simulate the ring or semilunar type of gall stones. The respiratory movement of the costal cartilages is so characteristic and so different from the respiratory movement of gall stones that difficulty in diagnosis can only arise with poor technique.

Intrahepatic calculi are rare are usually multiple and are distributed over such a wide area that they cannot possibly be in the gall bladder. They are composed almost entirely of calcium carbonate and are much denser than the average gall stone. *Calcified hydatid cysts* in the liver and *calcified liver abscesses*



FIG. 230 Two calcified stones in the gall bladder are very large.

making this differential diagnosis although it can be done by pictures in different postures and different phases of respiration. A calcified aneurysm of the renal artery simulating a gall stone has been described.

Cholecystography and Gall-stones

In about 50 per cent of cases of gall stones no shadow is obtained by cholecystography. This is due either to a stone blocking the cystic duct or to the gall bladder mucosa being so damaged that it cannot concentrate the dye. The exact diagnosis is not of great moment as the complete absence of a shadow calls for surgical treatment.

In about 30 per cent of cases the gall bladder shadow is faintly visible and the stones are clearly visible in it. Non opaque stones are seen as round or faceted areas of transluency. If there are many of these stones the diagnosis is easy; if there are only a few the diagnosis may be very difficult as gas shadows in the duodenum and colon cause very similar appearances. Oblique views and views in different postures with compression may solve the problem but the most effective method is to complete the examination and study the gall bladder after a fatty meal. When the gall bladder is contracted stones while still remaining inside its shadow alter their position and are usually

show dense peripheral rings of calcium, and do not change their relative positions in the supine and prone positions. These calcifications are not often confused with gall stones but may simulate calcifications of the gall bladder itself.

Pancreatic calculi are dense stones composed almost entirely of calcium carbonate. They are rare and usually multiple with the greater number lying in the left hypochondrium. A solitary pancreatic calculus in one of the larger pancreatic ducts has an oval shape rather like a ureteric calculus.

Suprarenal calcification is rare but may be similar to gall stones. A cholecystograph is the best method of

forced down to the fundus. In the erect position stones usually, but not always fall down to the fundus.

In about 10 per cent of cases the gall bladder concentrates the dye normally and the stones are visible in it. The method of differentiating the stones from gas shadows is the same as in the previous paragraph. It is sometimes

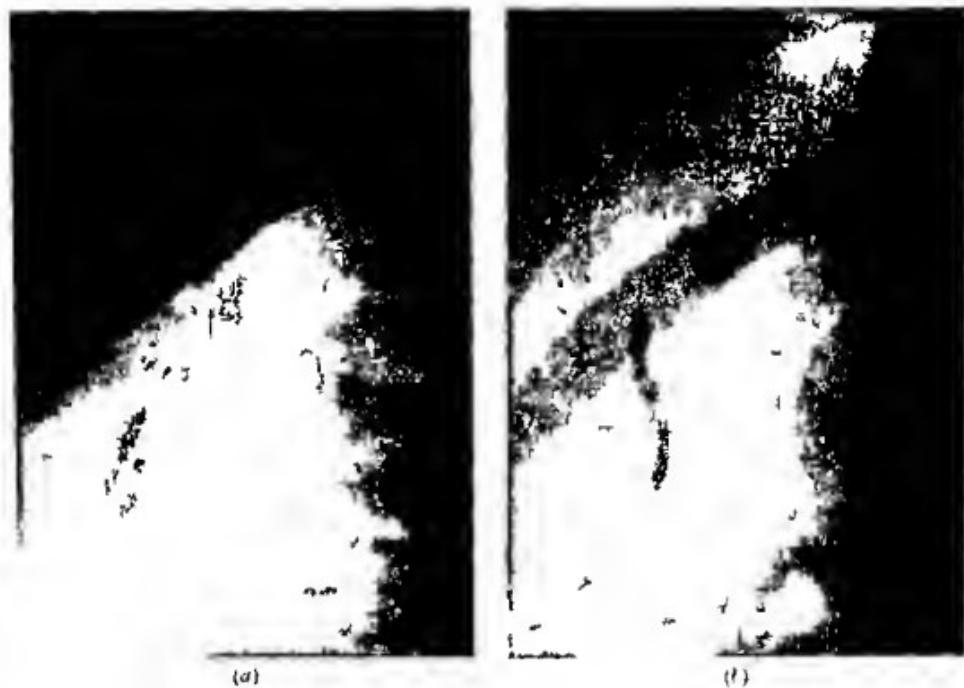


FIG. 231. A case of chronic calculous cholecystitis. Two stones were present in the cystic duct and the gall bladder contained aqueous fluid.



(a) and (b) show the variable vermiform shadow cast by the gall bladder at a month's interval. (c) is the excised gall bladder. No concentration occurred with intensified oral cholecystography.

erroneously stated that if there is normal concentration of the dye with stones the gall bladder is functioning normally and the stones are simply foreign bodies doing no harm. It cannot be over-emphasised that the degree of concentration of the dye is no index of the proper function of the gall bladder—it simply means that there is enough healthy mucosa left to concentrate. The rate of emptying of the gall bladder w

always slow taking often three or four hours to evacuate completely. This means that there is considerable fibrosis of the walls and is an indication for surgical treatment.

In about 10 per cent of cases a gall bladder containing cholesterol stones concentrates the dye normally and the concentrated dye conceals the stones completely. The first pictures are those of a normal gall bladder but during



FIG. 3.—A case of chronic calculous cholecystitis. The large round opacity is caused by calcium carbonate sand in the fundus; the small one by a calcium carbonate stone in the cystic duct. A calculous gallbladder is present below. No concentration occurred with oral chole-estoglycine and analysis of the contents of the gallbladder excised a few days later revealed no trace of tetraiodophenolphthalein.

the phases of contraction the stones often reveal themselves as translucent shadows and there is delay in evacuation. Even then however such stones may be invisible with routine technique. As already mentioned some of these small calculi have a lower specific gravity than concentrated bile and float. In interesting papers *Ellinger* and *Bradford* show how these calculi can be demonstrated in the erect position by gentle pressure with a compressor. In the erect position the concentrated bile falls to the bottom of the gall bladder and with gentle pressure the stones can be seen as small translucent shadows lying horizontally above this. The pictures should be taken with varying degrees of pressure. It is obvious that strong pressure will either force such stones up into the gall bladder mucus or down into the concentrated bile.

Stones in the common duct are very seldom visualised. Rarely the gall bladder may be seen full of faceted stones and one or two similar stones may be visible well away from the main shadow and in the line of the common duct. It may be assumed from the faceted shape that the stones developed in the gall bladder and passed into the duct. A stone developing in the common



FIG. 933.—Small calcified carbonate stones visible through a gas distended hepatic flexure in the oblique view.

duct itself is oval in shape like a ureteric or pancreatic calculus. The differential diagnosis from a ureteric calculus is easily made by a cholecystography or a pyelography but it may prove impossible to distinguish between a pancreatic and a common duct calculus.

CALCIFICATION OF THE WALLS OF THE GALL BLADDER

This is a rare occurrence. It cannot occur without extensive pre-existing fibrosis and is therefore a sequel to a chronic cholecystitis. In the continental text books it is described as the porcelain gall bladder. The diagnosis is easy and the calcified walls are clearly visible on plain radiograms. The calcium is laid down symmetrically and the usual ovoid outline of the gall bladder is

FIG. 36.—(a) Prone position. Oysters on bar to a calcified plan in front of the 3rd limestone. (b) Oblique section showing the 1st limestone. (c) Oblique section showing the 2nd limestone.

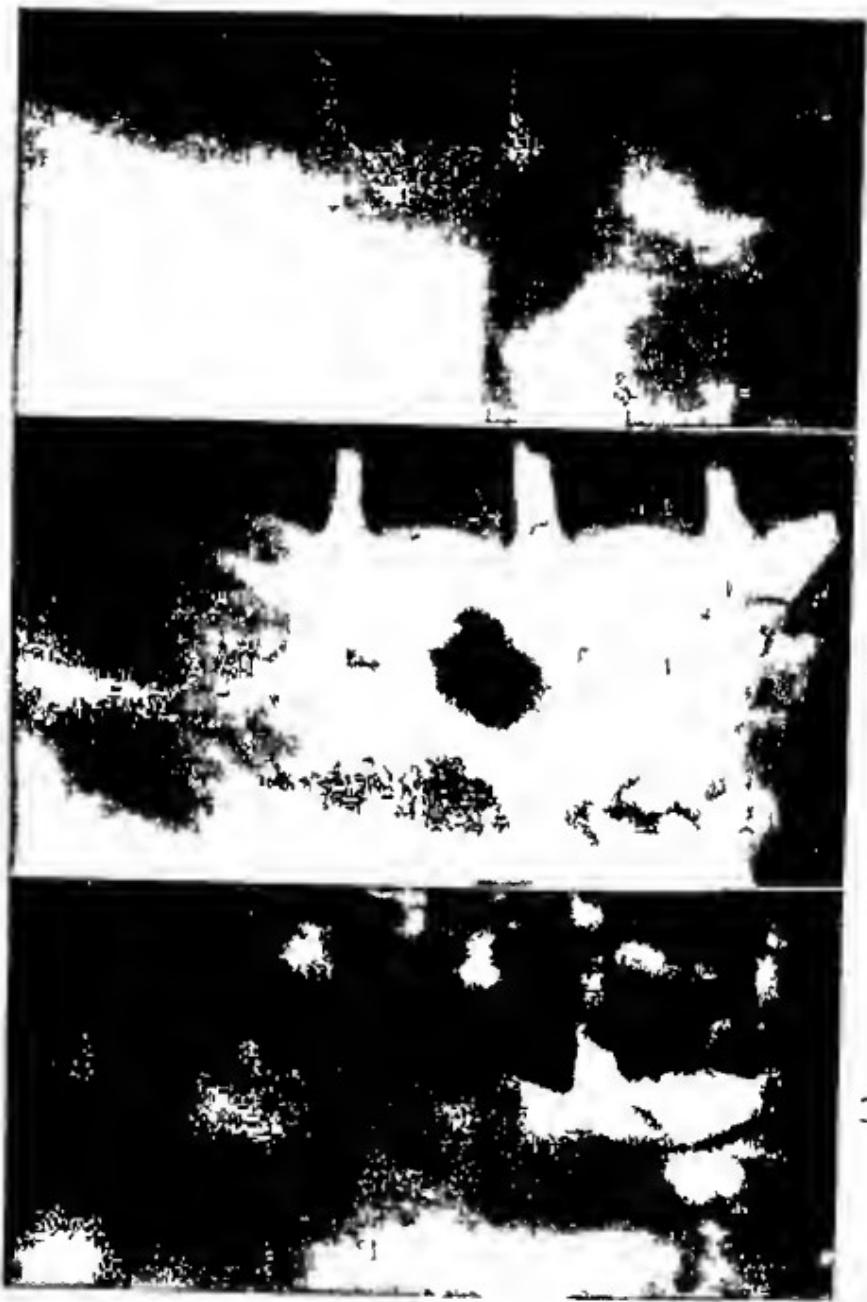


FIG. 235.—A case of multiple acistic gall stones (→) in the numerous small calculi in the right kidney. These two collections of shadows were grouped rather closely together and are here shown differentiated by intravenous urography.



FIG. 236 (a).—An apparently normal gall bladder in the prone position.



FIG. 236 (b).—The same case erect showing floating gall stones. These appear as a thin translucent line above dense bile in the fundus. (Courtesy of Dr. J. F. Bradford.)

visible. It is possible that a calcified gall bladder of the round or stemic type would give an appearance identical with a calcified hydatid cyst. Cholecystography will differentiate these two conditions, a normal gall bladder filling taking place in the case of hydatid disease. At a clinical meeting of the British



FIG. 37. Opaque faceted stones in the gall bladder through the cystic duct and the common duct. The faceted shape of the stones in the duct shows that they originated there from the gall bladder.

Institute of Radiology a case was shown in which two very large gall stones of the ring type simulated calcification of the walls. The differential diagnosis is not of importance as both conditions are surgical. The calcified gall bladder either completely fails to concentrate dye or concentrates it feebly and slowly.

THE NON-CALCIFIED GALL-BLADDER VISIBLE WITHOUT CHOLECYSTOGRAPHY

Occasionally a well-defined gall bladder shadow is visible on a preliminary radiogram. It has the usual ovoid shape and can be clearly distinguished

from the liver and kidney shadows. This appearance has been recognised and discussed for many years but we are still uncertain as to whether it represents disease in the gall bladder or not. *Anox* was of the opinion that it was normal and he was supported by many workers in Europe. Most American workers are inclined to the view that spontaneous visibility of the gall bladder is pathological. If we consider the factors responsible for radiological visibility of an organ it is remarkable that the normal gall bladder is not seen more often. Calcium is excreted into the bile by the liver in relatively large quantities. Liver bile, according to *Neuman*, contains 60 mg of calcium per 100 c.c.m. of bile and this is further concentrated in the gall bladder.

Although *Carman* was of the opinion that gall bladder bile was no more opaque than liver bile his experiments were not valid and there is no doubt at all but that gall bladder bile must be more opaque. The quantity of calcium in normal gall bladder bile is very often much greater than the quantity in gall stones which can be clearly visualised. Many workers ascribe the visibility of the gall bladder to a greatly increased concentration of the bile which is described as gall bladder mud. This theory will not fit in with clinical or physiological facts. *Hiltaker* has shown experimentally that the gall bladder ceases to concentrate after twenty four hours so that even if there is stagnation for longer



FIG. 38.—Calcification of the gall bladder



FIG. 39.—Radius mm. of the gall bladder shown in Fig. 38 after removal

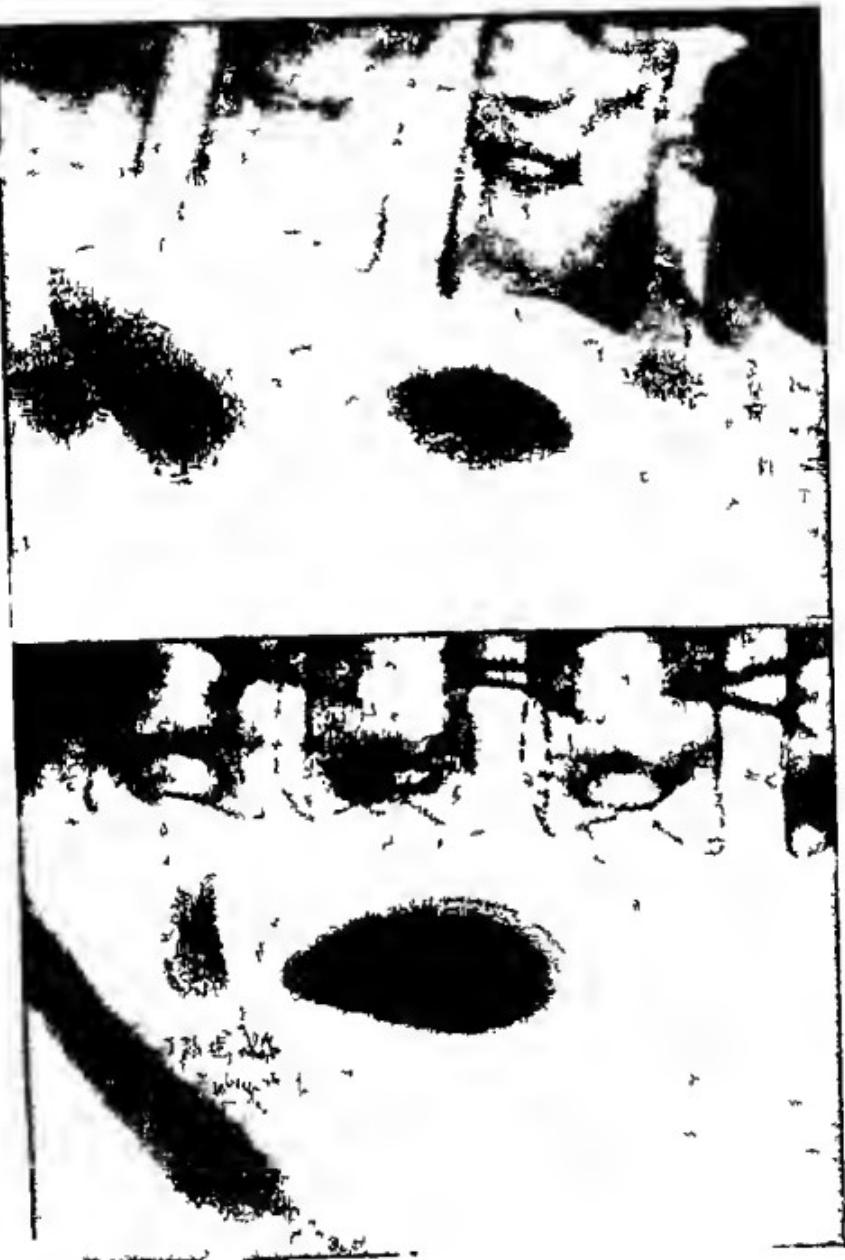
than this period the density of the bile remains the same although it may look blacker and thicker to the eye. It is an interesting fact that much fewer reports of spontaneous visibility of the gall bladder have appeared since the introduction of cholecystography. It is obvious that the only certain method of checking the biliary function is by cholecystography and this should be done in all these cases. The radiological diagnosis of gall bladder mud should be discarded.

BILIARY DYSKINESIA

The neuro muscular mechanism of the gall bladder and ducts has already been described in the chapter on the normal. Disturbances of this mechanism are not infrequent and cause symptoms very difficult to distinguish from symptoms of organic disease. The possibility of functional disturbance being responsible for gall bladder pain was long suspected but it is only in recent years that the question has been adequately explored. Neerman's Coulstonian lectures give an admirable and exhaustive survey of the clinical problems involved. It has been shown that overaction of the vagus causes spasm of the gall bladder and ampulla and cessation of the flow of the bile while stimulation of the sympathetic causes relaxation of the gall bladder and ampulla with contraction of the sphincter of Oddi and again no flow of bile. The former condition causes spastic distension and the latter causes atomic distension of the gall bladder. The symptoms in both cases are the same i.e. gall bladder pain. It is obvious that in both conditions bile will flow normally into the gall bladder and will be concentrated there but in both cases there will be disturbance of the rate of emptying and probably dilatation of the common duct. Neerman's lectures were delivered before it was realised that the ducts could be visualised in most cases. He describes the cholecystographic appearances of spastic distension as follows: 'There is an opaque well filled well-concentrating gall bladder which diminishes after the fatty meal but does not disappear and which shows a delay in emptying'. In atomic distension cholecystography shows a very long thin gall bladder which throws a poor shadow and empties very little. Spastic distension is associated with a hypertonic stomach and hyperacidity while atomic distension is associated with a low atomic stomach and hypacidity. In both forms of the condition the common duct may be dilated and although the subject has been practically unexplored by radiology there are a few records by Bronner and Nemours.

In just showing such dilatation Moreover Nemours Auguste has demonstrated regurgitation into the intra hepatic ducts and there is no doubt but that the occasional reports of barium flowing into the ducts is due to some disturbance of the neuro muscular mechanism. In the case illustrated in Fig. 240 there is clearly a spasm in the middle of the cystic duct. This type of dyskinesia does not appear to have been described before. Now that we can demonstrate the ducts the radiological diagnosis of biliary dyskinesia is comparatively easy and cholecystography will at last throw light on those obscure

FIG. 240.—*Bilary fistulæ* I male et 30 Clariætæ the attacks of bilary fistulæ normal (a) An epiphysial lumen (b) The same one year after two fatty meals D stems on gall bladder and luctus 1 mm in radius after fistula (c) The same one year after fistula of 10 cm and part of the cysto-rectal junction removed. The space is occupied by muscular tissue.



cases where there is definite clinical evidence of gall bladder pain with a normal concentration of the dye in the gall bladder. There are many degrees and varieties of biliary dyskinesia—to appreciate these and their possible effect on cholecystography appearances the clinical picture should be studied in *Neuman's* work.

PERICOLECYSTITIS (ADHESIONS)

In most cases pericolecystitis is a sequel to or a complication of cholecystitis. Provided the gall bladder can concentrate the dye such adhesions can be demonstrated. If the gall bladder in the prone position is parallel to the lower border of the liver adhesions between the fundus and the liver are probable and if the same relationship is maintained in the erect position adhesions are certain. *Bronner* has demonstrated adhesions between the neck and the common duct with a ragged outline of the duct showing during the phase of contraction. Adhesions to the duodenal cap and second part of the duodenum are not uncommon. A gall bladder impression on the cap is not necessarily pathological but if this appearance persists and if the cap is irregular in outline there are probably adhesions present. Adhesions to the second part of the duodenum displace the bowel upwards and to the right and in some cases tenting of the outer wall of the bowel is visible. Occasionally an adhesion runs across the common and cystic ducts and prevents the cystic duct unfolding when the gall bladder contracts rather like a string being tied around a loop of hose pipe and preventing it unfolding when the pressure of water enters. *John Hunter* in a personal communication states that he has seen three or four cases of this nature at operation. There were typical symptoms of gall bladder distension with a normal cholecystography and at operation the gall bladder was normal. The obstructive symptoms were entirely due to the small adhesion. Had these cases been investigated by modern technique marked delay in emptying would have been found. Occasionally an abnormal peritoneal fold—the cysto duodenal or cysto colic ligament takes this course across the common and cystic ducts and it is possible that this ligament might cause similar partial biliary obstruction. The question is of some importance as it is going to prove very difficult to distinguish between dyskinesia and distension due to adhesions or abnormal ligaments.

Adhesions between an inflamed gall bladder and the hepatic flexure are not uncommon. Such adhesions are nearly always associated with typical gall bladder pain and a cholecystography reveals a pathological gall bladder. Rarely tenting upwards of the upper border of the proximal end of the transverse colon is visible. There are occasional reports in the literature of cholecysto colonic fistulae. *Startz* and *Medelman* have described typical cases of this nature recently. The patient complains of diarrhoea with a history of sudden onset of the diarrhoea. The stools are frothy and brown to clay coloured. There is some loss of weight and discomfort in the right hypochondrium. In

both of the author's cases a barium enema passed normally round to the hepatic flexure and then filled the gall bladder and the biliary and hepatic ducts. Perforation into the small intestine does not appear to be so frequent. A barium meal will not necessarily flow from the duodenum into the gall bladder in such cases, and the meal may give no clue to the causation of the symptoms. Occasionally a large gall stone passes into the small intestine through such a

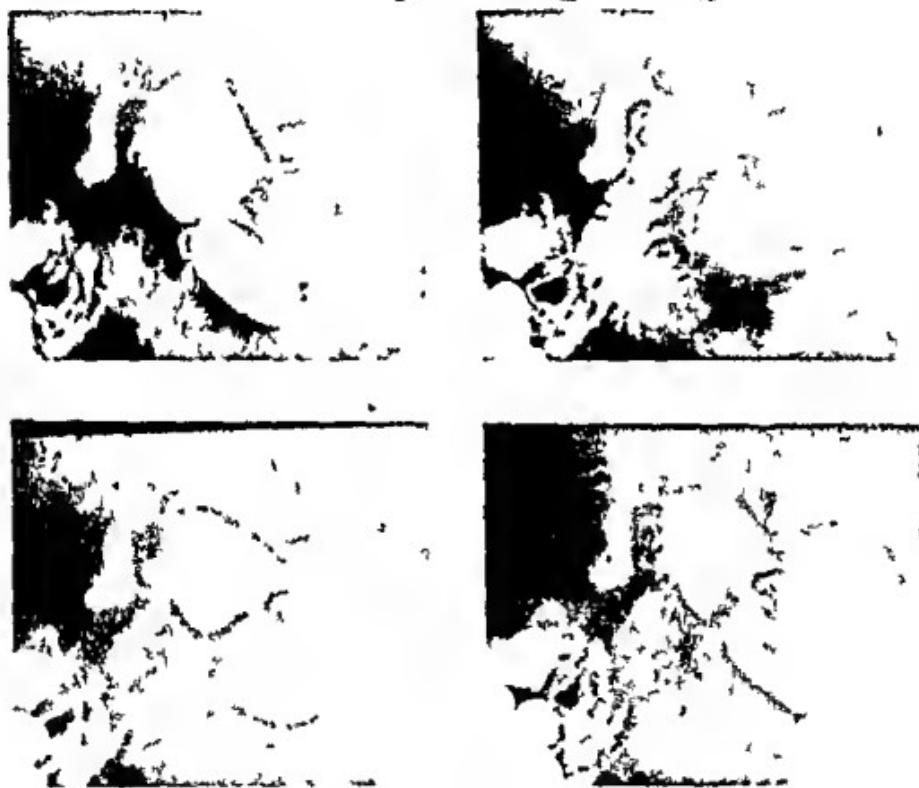


FIG. 241.—Several views of the duodenal cap showing a duodeno-biliary fistula. The gall bladder is filled with barium.

fistula and causes acute or subacute intestinal obstruction. The author examined a case of this nature and found one large stone clearly visible in the gall bladder. Although the history strongly suggested that another stone had been ruptured into the small bowel, this stone could not be visualised, and a meal gave no help other than the demonstration of distended coils of the small intestine. At operation a stone about the size of a shilling was found impacted in the ileum. Not infrequently a gall stone attack causes symptoms of

intestinal obstruction without any passage of stones into the bowel. The diagnosis of such cases is most difficult—if a barium enema reveals no pathology in the large bowel following an attack of apparent intestinal obstruction the radiologist should make a careful examination of the gall bladder area. Rarely gall stones rupture into the anterior abdominal wall. The author examined one case of this nature. The patient was an elderly woman complaining of abdominal pain and nausea with slight loss of weight. Clinical examination revealed a large hard mobile mass in the region of the hepatic flexure. A barium meal showed no abnormality of the gastro-intestinal tract but there were three large gall stones of the ring type in the region of the palpable tumour. An oral cholecystography gave a completely negative result. At operation the three large stones were found embedded in the anterior abdominal wall and the gall bladder contained several small non-opaque stones.

TUMOURS OF THE GALL-BLADDER

We are indebted to *Aurkin* for our knowledge of the X-ray appearances of neoplasms of the gall bladder. *Small papillomas* are the most frequent

These give characteristic appearances. They are seen as small translucent defects usually on the lateral walls of the gall bladder. Their average size is about $\frac{1}{2}$ cm and they are not larger than 1 cm. They are multiple and two or three appear to be about the average number present. The gall bladder in most cases concentrates the dye well. The defects always maintain the same relative position in the gall bladder irrespective of changes in posture or phases of contraction. The appearance in the filled gall bladder resembles stones or small pockets of duodenal gas. Stones however alter their position during the contraction of the gall bladder and duodenal gas can usually be eliminated by pressure or changes in posture.

Adenoma of the gall bladder is a rare tumour. It occurs most often in the fundus and appears as a single small semicircular or circular translucent de-

Fig. 242. Multiple papilloma of the gall-bladder confirmed at operation.

fect in the fundus of a well-filled gall bladder. An adenoma is best visualised when the gall bladder has contracted down and evacuated about half of its contents. Like papillomas, an adenoma never alters its position.



Primary carcinoma of the gall-bladder is not common. Statistics show that in most cases carcinoma develops in a gall bladder containing stones. Cholecystography has not materially assisted in the diagnosis of cancer. In most cases there is a completely negative filling, in some cases stones may be visible, without, however, any clue to the presence of a growth, and in one case Kirillin found a normal concentration of the dye. Taterka has reported one ease in which there was a filling defect of the outer wall and an indentation of the inner wall.

Tumours of the bile-ducks are rare. The author, in one case of primary carcinoma of the hepatic duct, found a complete failure of concentration.

POST-OPERATIVE VISUALISATION OF THE BILIARY TRACT

This procedure has attracted more attention in America and the Continent than in England. The object of the examination is to determine the patency of the common duct and the efficiency of drainage after choledochostomy. It is often very difficult to palpate small stones in the common duct at operation. Lipiodol, or some similar substance such as brominol, is slowly injected through the drainage tube into the ducts under the screen. The reader is referred to a paper by Hufford for details of the technique. It is imperative that the injection be made slowly and under the screen, as, if some of the opaque material is forced into the duct of Wirsung, it may precipitate oedema of the pancreas or acute haemorrhagic pancreatitis. When the opaque material has been injected pictures are made at intervals of fifteen minutes, and the patency of the common duct checked by the appearance of the lipiodol in the duodenum. The calibre of the common duct and the time taken for the flow of lipiodol into the duodenum are carefully observed, particular attention being paid to the presence or absence of small defects in or constrictions of the common duct. The intrahepatic ducts are often filled. These appear rather like the lipiodol filled bronchi, progressively diminishing in size, and terminating in fine sharp pointed arborisations. Dilatation of the intrahepatic ducts with clubbing of the terminal branches is an indication for prolonged drainage, and also signifies that the biliary infection necessitating operation was present for a considerable time.

DISEASES OF THE LIVER

The visualisation of the liver and spleen by direct radiography is unsatisfactory. It was found that radioactive substances, when injected into the blood-stream, tend to be retained in the reticulo-endothelial system—as these substances are of high specific gravity they are radio-opaque, and one of them, thorotrust, has been employed for radiography of the liver and spleen. The results obtained did not materially assist diagnosis or research, and as the half value period of thorotrust is high and the substance is known to be carcinogenic in animals, the method is falling into disuse.

More important, from the radiologist's point of view, are the liver necroses. In acute liver necrosis, cholecystography is contraindicated. There are, however, cases of idiopathic jaundice associated with subacute necrosis of the



FIG. 243. Lipiodol cholangiogram in a case of biliary fistula following destruction of the common bile duct. The gallbladder had been removed. The irregular mass of lipiodol is on the skin and in the sinus and the straight tube represents the dilated hepatic duct.

liver. There are many degrees of subacute necrosis and the condition does not appear to be very rare. Cullinan having recently published twenty proven cases. The etiology is completely unknown bacterial infections, syphilis, alcoholism and drugs having been excluded. In some of Cullinan's cases

cholecystography was carried out and showed either a poor concentration or a complete failure to concentrate. This was interpreted as being due to a pathological gall bladder but Cullinan thinks it was more likely due to a damaged power of excretion of the liver itself. Thus finding is of much interest because (a) it shows that cholecystography is not necessarily dangerous in cases of jaundice and (b) it reveals another and apparently not infrequent condition which may be responsible for poor or absent concentration. If Whistler's and Fried's experiments on dogs are valid in human beings cholecystography will not cause distress and the dye will be concentrated normally when roughly half the liver is put out of action by necrosis. Generally speaking it is wiser in cases of jaundice to make use of the single dose oral method.

THE GALL-BLADDER AFTER CHOLECYSTOSTOMY

Jerkinson and Foley followed up a series of 28 cases who had had surgical drainage of the gall bladder. They found 19 concentrated the dye normally and contracted normally after a fatty meal. Seven showed feeble concentration or complete failure to concentrate and 2 showed a normal concentration with visible stones.

THE EFFECT OF EXTRABILIARY DISEASE ON CHOLECYSTOGRAPHIC FINDINGS

Most textbooks on the radiology of the biliary tract cite numerous extrinsic conditions as being potential causes of failure of the gall bladder to concentrate the dye. Cullinan has shown that the gall bladder will to some extent concentrate the dye in cases of advanced liver disease. Neuman has established that in the neuro muscular disturbances of the biliary tract there is no failure to concentrate although such disturbances are frequently associated with functional disturbances of other organs. It has been stated that the gall bladder does not concentrate the dye in the late stages of pregnancy but this requires verification on a large series of cases with the intravenous technique. In a very interesting paper Good and Kirklin analyse the cholecystographic findings in 733 cases of peptic ulcer, pernicious anaemia, thyrotoxicosis, myxoedema, diabetes, obesity, pulmonary tuberculosis and chronic appendicitis. Of the 733 cases 157 had abnormal cholecystographic findings in the form of a poor or absent shadow. Of these cases 104 had the gall bladder examined either at operation or autopsy and the cholecystographic findings indicating gall bladder pathology were confirmed. In only 2 of the cases was a normal gall bladder found at operation i.e. an error of 1.9 per cent. These findings show that extrinsic diseases both metabolic and abdominal have little or nothing to do with the ability of the gall bladder to concentrate and excrete the dye. The majority of errors in diagnosis are made on the interpretation of poor shadows such errors would soon be eliminated if radiologists checked their poor shadow findings in the operating theatre.

REFERENCES

- ANTONELLI, C., "Rapid Cholecystography," *Presse Med.*, June, 1932, 983.
- BOYDEN, E. A., "The Accessory Gall bladder. An Embryological and Comparative Study of Aberrant Vesicles Occurring in Men and Domestic Animals," *Amer J Anat.*, 1926, 177, "Behaviour of the Human Gall bladder during Fasting and in Response to Food," *Proc Soc Exp Biol and Med.*, 1926-27, XXIV, 157, "An Analysis of the Reaction of the Human Gall bladder to Food," *Anat Rec.*, 1923, XXXIX-XL, 147-192.
- BRAILSFORD, J. F., "Use of the Erect Position in Cholecystography for the Demonstration of Floating Gall stones," *Brit J Surg.*, October, 1937.
- BRÄUNSCHEIG, W., "Reduplication of the Gall bladder," *Röntgenpraxis*, 1933, 504.
- BRONNER, H., Results of Investigation of the Gall bladder Motility by Cholecystography, *Fortschr a d Geb d Röntgenstr* Jan., 1929.
- CULLINAN, F. R., "Idiopathic Jaundice Associated with Subacute Necrosis of the Liver," *St Bar's Hosp Reps.*, XXXIX, 55.
- ETTINGER, ALICE, "Visualisation of Minute Gall-stones," *Amer J Roentgenol.*, Feb. 1936.
- FLINT, E. R., "Abnormalities of the Right Hepatic, Cystic, and Gastroduodenal Arteries and of the Bile ducts," *Brit J Surg.* 1922 X, 509.
- GOOD, C. A., and KIRKLIN, B. R., "The Influence of Extrabiliary Disease on the Function of the Gall bladder," *Amer J Roentgenol.*, March, 1937.
- GRAHAM, COLP, COPHER and MOORE, "Diseases of the Gall bladder and Bile ducts," London, 1929.
- GUTMAN, R. H., See DEMOURES ARGETTE 96.
- HARTING, A., "Gall bladder on the Left Side," *Röntgenpraxis* 1932 393.
- HUFFORD, C., "Post-operative Visualisation of the Biliary Tract," *Amer J Roentgenol.*, Feb., 1937, 154.
- JENKINSON, F. L. and FOULI, J. M., "Cholecystographic Findings following Cholecystectomy," *Amer J Roentgenol.* Sept., 1936.
- KIRKLIN, B. R., "Cholecystography," *Brit J Radiol.*, 1935 VIII, 170.
- KNOTT, R., "Radiography in the Examination of the Gall bladder," *Arch Radiol and Electrother.*, July, Aug. and Sept., 1919.
- MACKAULT, quoted by ROLLESTON and MCNEE, *Inn Surg.*, London, 1910, 651 and 1910, 131.
- MEDELMAN, J. P., "Cholecytic-colonic Fistula," *Ibid.*, July 1930.
- MOTTMAN, LORD, quoted by ROLLESTON and MCNEE, *Brit Med J.*, I, 1.
- DEMOURES ARGETTE, "The Radiology of the Biliary Tract," Paris, 1934.
- NEWMAN, C., "Physiology of the Gall bladder and its Functional Abnormalities," the Goulstonian Lectures for 1923, *The Lancet* 1923, April 15th, 22nd, and 29th 785, 841, and 896.
- ROLLESTON, SIR H. and MCNEE, J., "Diseases of the Liver, Gall bladder and Bile ducts," London, 1919, 3rd Edn.
- ROWDEN, L., Chapter on the Gall bladder in BAILEY & "The Digestive Tract," Cambridge, 1933.
- STARTZ, I. S., "Cholecytic colonic Fistula," *Amer J Roentgenol.*, October, 1936.
- STEWART, W., and ILLICK, H., "Advantages of Intensified Oral Cholecystography," *Amer J Roentgenol.*, 1935 XXXIII, 624.
- TATERKA, "Cholecystographic Examinations," *Röntgenpraxis*, 1931, 731.
- WESTGAARD, B., "Muscle Function, Innervation, and Pathology of the Biliary Tract," *Zeitscr f Klin Med.*, 1923 XCVI, 22.
- WHITAKER, L., "The Double Oral Method for Cholecystography," *Amer J Roentgenol.*, February 1936, "The Mechanism of the Gall bladder," *Amer J Physiol.*, 1926, LXVIII, 411, "Experiences with Cholecystography including Observations on the Function of the Gall bladder," *J Amer Med Assoc.*, 1926, LXXXVI, 239.
- WHITAKER, L., and FRIED, B. M., "The Effect of Liver Damage on Cholecystography in Dogs by the Use of Sodium Tetrachlorophenolphthalein," *Arch Int Med.*, 1926, XXXVII, 399.
- ZAPPALA, quoted by ANTONELLI, C., *Presse Med.*, June, 1932, 985.

PART THREE
THE ABDOMEN

BY

S COCHRANE SHANKS, M D, F R C P, F F R

PART THREE
THE ABDOMEN
CHAPTER XXIX.

THE LIVER, SPLEEN, PANCREAS AND ADRENALS

THE LIVER

General Hepatic Enlargement—This may be due to many causes, such as congestion, cirrhosis, tumours or hydatid disease.

There are certain anatomical features in the liver of radiological importance. The upper surface is in contact with the diaphragm, the left border extending on an average half way across the left dome. Its contour is therefore clearly visible in a radiogram except where its shadow fuses with that of the heart. The right surface is in contact with the lateral abdominal wall, and can usually be made out in a film of good quality. Frequently also the anterior and right lateral margins of the liver are visible. The outline of the anterior margin gradually disappears to the left. In spite of this, accurate estimation of slight or even moderate enlargement is impossible, because of the varying obliquity of the inferior surface. Only when the enlargement is considerable can it be shown radiologically with certainty, and then the condition is evident clinically.

The shape of the hepatic shadow varies with the habitus. In hypersthenic subjects it is wide and shallow, and high in the abdomen. In hyposthenes its transverse diameter is less, its depth increased and the indentation of the waistline of the patient is frequently visible on the right. The hepatic flexure and transverse colon if outlined with gas or barium may delineate the lower surface approximately but without any precision since they themselves are so variable in position. *Löffler* in 1914 pointed out that if the colon is inflated the transverse portion usually lies against the lower surface of the liver, and this provides a more accurate boundary mark but the method is very seldom used now.

Angulation of the tube so that its central ray is in the plane of the lower surface of the liver may intensify the shadow of the lower margin (*Köhler*).

Hepato-henography—For this examination thorin is used as a contrast medium. This element has an atomic number of 116 (atomic weight 232), and is one of the heaviest metals known. In suitable non-toxic combination it forms a dense and very satisfactory medium in relatively dilute solutions.

It is used in two forms stable and flocculent. The flocculent form diagnose thorine is described in the section on the colon. An example of the stable form is thorotrust described by the makers Heyden of Dresden as a stabilised thorium dioxydsol containing 25 per cent ThO₂ in sterile suspension and supplied in ampoules containing 25 c.c. It is miscible with water or normal saline without disturbance of the suspension.

Thorotrust is used in two different classes of contrast medium work—intravascular and intraluminal. In the former category are arteriography and hepato-pancreasography; in the latter are urography and demonstration of fistulae, empyema cavities, etc.

PROPERTIES—Thorotrust is very opaque to X-rays even when diluted threefold; this quality makes it of value when only a small quantity or a thin layer can be introduced.

Although it was originally claimed to be quite non-toxic in the doses recommended in intravenous or intra-arterial injection and non-irritant when introduced into the bladder and kidney, one feature must be borne in mind—its radioactivity. This is very slight but since the reticulo-endothelial system stores thorium dioxide indefinitely when the latter is injected intravascularly late degenerative changes are apt to occur in the liver and spleen in the course of years. Indeed numerous cases of such damage are now being reported in the literature. It is therefore not a medium to be lightly used intravascularly. This fear of damage by radiation does not apply in the other uses of thorotrust e.g. pyelography.

ADMINISTRATION FOR HEPATO-PANCREASOGRAPHY—A total dose of 50–75 c.c. of thorotrust is usually necessary given over a period of several days. An initial intravenous dose of 10–15 c.c. depending on the size of the patient should be given slowly over three to five minutes on the first day. As a rule no after-effects result but occasionally slight headache and rise of temperature may occur. Subsequent injections should be given daily if there are no after-effects and every second day if there are until the required dose has been given. In the absence of symptoms it is safe to increase the daily dose to 20–25 c.c. but if after-effects have occurred it is better to keep the dose low.

The radiographic examination should be made one or two days after the last dose to allow concentration of the drug to take place in the reticulo-endothelial system. The radiographic technique should be directed to obtaining the greatest possible degree of contrast since the degree of concentration is not great.

RADIOGRAPHIC APPEARANCES—These have been described by *Ladislav Policer*. As a result of the fixation of the thorium salt by the cells of Kupffer in the liver and spleen these organs cast a much denser shadow than normally and their outlines in a radiogram become clearly defined.

The chief value of the method is in the demonstration of hepatic metastases. These, since they do not become uniformly radiopaque with thorium, stand out as clear

areas in the hepatic shadow. *Hydatid cysts* are similarly delineated. *Volicer* states that in advanced cirrhosis of the liver the concentration of thorium is poor and that the physiological rhythmic contractions of the spleen can be observed fluoroscopically. The method is said by *Volicer* to be contra indicated in diseases of the reticulo-endothelial system.

Thorotrust hepatography and pneumoperitoneum may both give accurate information regarding the liver but the now well known damage which thorium may do to the reticulo-endothelial system precludes its use in the vast majority of cases and the information obtained by the latter method is usually not worth the inconvenience of the examination.

Abscess of the Liver — The small multiple metastatic abscesses following on pyphlebitis or ulcerative endocarditis give no radiological signs. The larger amoebic abscesses may cause enlargement of the liver and elevation and fixation of the right dome. The nearer the abscess is to the upper surface of the liver the more definite are these signs. The dome is not usually deformed even with a subdiaphragmatic liver abscess but in this type the differential diagnosis from subphrenic abscess may be impossible.

Carcinomatous metastases of the liver are very common. Apart from the advanced cases in which a mass can be seen projecting from the lower margin of the liver and the extremely rare calcifying metastases radiology is of little help. Any general enlargement shown in a radiogram is also evident clinically. Thorium hepatography is now regarded with disfavour even in this condition. It shows intrahepatic metastases clearly and may by doing so spare the patient an unnecessary laparotomy. In such a case thorium damage is of no consequence but if no metastases are present and the primary lesion in the alimentary canal is removable the damage caused by thorotrust is of importance and the method should therefore be avoided.

Calcification in the Liver — The liver is the common site of hydatid cysts. They may be multiple and reach a large size. If near the upper surface a cyst may cause a localised rounded elevation of the diaphragmatic contour and if near the anterior margin a rounded downward projection of that edge (*Harrison*). More commonly however they are not radiographically recognised until they become calcified as often happens. As the wall calcifies an irregular trabeculated ring shadow of the wall appears the arrangement depending on the distribution of calcification and the arrangement of the cysts.

Limard reports a case of tuberculous abscess of the liver which had undergone caseous sclerosis and cast an irregular shadow simulating gall stones.

Freese reports two cases (1) Opacities the size of cherry stones scattered throughout the liver and thought to be due to calcified tuberculous foci (2) A large irregular calcified mass capping the upper surface of the liver from a calcified subphrenic abscess.

Other conditions in the liver which may rarely become calcified are hemangioma and lymphangioma, abscess, gumma and metastatic carcinoma.

THE SPLEEN

Anatomy — The spleen lies posteriorly in the left hypochondrium between the gastric fundus and the diaphragm. It is an oblong flattened body about 5 inches long, 3 inches broad and 1.5 inches thick. It is held in position by the hemo renal ligament and the gastro splenic omentum. The outer convex surface is in contact with the diaphragm which separates it from the ninth, tenth and eleventh left ribs. Its inner surface is divided by a ridge into an anterior or gastric surface and a posterior or renal. Two other relationships may be noted, that of the lower pole of the spleen to the splenic flexure of the colon and that to the tail of the pancreas. The long axis of the spleen runs from above downwards, outwards and forwards.

Radiological Appearances — The normal spleen is visible only if contrasted medially against gas or other medium in the stomach and/or colon. Usually its upper pole is to some extent visible against the gastric gas bubble and if the splenic flexure is distended with gas its whole inner contour may be seen but percussion and palpitation give such accurate information regarding its position and size that radiographic examination is seldom if ever necessary.

If it is necessary to demonstrate the spleen radiologically the patient should be screened to determine which view (postero anterior oblique or lateral) shows it best and whether it is necessary to inflate the stomach and colon. Its normal outline is usually semilunar but may vary according to the angle at which it is projected.

PTOSIS OF THE SPLEEN is not an infrequent occurrence and is demonstrated only in the erect posture. Enlargement of the spleen is easily detected clinically and its radiological signs in addition to the increase in its shadow are those of displacement of the stomach to the right and of the left colon downwards.

CALCIFICATION IN THE SPLEEN may result from various lesions including the following: tuberculosis, infarct, hydatid disease, phlebolith.

CALCIFIED SUBACUTE TOXIC appear as multiple rounded irregular shadows usually small in size scattered in the splenic shadow. In the case reported by Spitz the opacities were small and sharply defined and the calcification well advanced. In one of Shands' three cases the opacities were larger and somewhat woolly due to active caseation in addition to the calcification.

SPLENIC INFARCT presents a typical radiological appearance when calcified. Although infarcts are not uncommon calcification in them is and so is rarely seen in an X-ray department. *Audrenka* and *Babaultz* describe the following features in three cases seen by them. The calcified lesion is of considerable size located in the spleen of triangular or oval form and may be single or double. The texture of the calcified shadow is not homogeneous but rather porous. If triangular in shape the base is to the outer convex surface and

its apex towards the hilum. The contours of the triangle are sharply defined, with minor irregularities only.

The shape of the infarct as seen in a radiogram—oval or triangular—depends on the angle at which the pyramidal lesion is projected on the film.

HYDATID CYSTS cause enlargement of the splenic shadow if not calcified, and, in addition, the typical trabeculated ring shadow if they are.

PHEBOLITHS are said to result from venous thrombi. They appear as small rounded shadows varying in size from 1 mm to 1 cm and may be multiple, as in the case reported by Koppenstein, or single as in one case noted by the writer.

Rare causes of calcification which have been described are atheroma of the splenic artery and perisplenitis.

THE PANCREAS

Anatomy.—The pancreas lies transversely on the posterior abdominal wall in the epigastric and left hypochondriac regions at about the level of the first lumbar vertebra. Its downward turned head, the largest part of the gland, is closely encircled by the duodenal concavity for about two thirds of a circle. Radiologically, the most important anterior relationship of the pancreas is the stomach, which lies in front of most of it, separated from it by the lesser sac. The duct of Wirsung opens into the second part of the duodenum, 3-4 inches from the pylorus, either directly or into the ampulla of Vater. The common bile duct, as it approaches the ampulla, is also closely related to the pancreatic head.

Technique of Examination—The pancreas is a difficult organ to examine radiologically, and a variety of measures may be necessary, depending on the lesion in question. They are:

(1) *The Plain Postero-anterior Film*—This may show gross enlargement or calculi, and in acute pancreatitis may give confirmatory signs.

(2) *The Barium Meal* may show a gastric or duodenal pressure ulcer. Twining's method is of particular value here. In this method the



FIG. 244.—Three splenic stones.



FIG. 245.—The posterior (pancreatic) incisura of Twining | lateral anterior supine view

pancreas surmounting a triangular filling defect due to the pancreas itself (Fig. 246)

The recognition that there is normally a triangular defect present in addition to the incisura proper is of importance in assessing the presence or absence of one due to a tumour of the pancreas or stomach bed.

(3) *Fluoroscopy of the Diaphragm and Lung Bases* should be carried out if an acute pancreatitis is examined radiologically.

(4) *The Barium Enema* may give evidence of steatorrhoea in chronic pancreatitis.

(5) *Lateral Radiography with Barium Inflation of the Stomach*—
The technique for this test according to Engel and Lysholm is important as follows:

The colon should be well cleared out and the stomach empty. The stomach is inflated via an Euhorn tube (which may first be used to empty it) and the patient told not to belch. If the patient objects to the passage of the tube an effervescent powder may be used but this necessitates swallowing some water which is a dread

well filled with barium emulsion is radiographed in the lateral (dextro-sinistral) view, with the patient lying supine, and the rays horizontally disposed. A Schonander grid is used.

Twinning points out that in many ptotic women a normal incisura is present on the posterior wall of the stomach at the level of the pancreas (the 'posterior pancreatic incisura'). This shows itself in the postero-anterior supine view as an indentation of the greater curve sometimes extending right across the stomach but more frequently fading away towards the lesser curve (Fig. 245). In the lateral supine view this incisura is seen to be an infolding of the gastric wall at the



FIG. 246.—The posterior (pancreatic) incisura of Twining | lateral supine view

vantage. Whichever method is used, the lateral radiogram must be taken immediately after the inflation, before any appreciable quantity of gas has escaped into the small intestine. In that site the gas may cast confusing shadows.

The patient should be prone with the chest and pelvis supported by flat pillows or pads to prevent undue pressure on the air filled stomach. Alternatively he may be supine, but this position gives a less prominent shadow of a tumour.

The tube is centred horizontally on the right loin, and the film placed on the left. A Schonander grid may be used with advantage. Immediately following this, the essential view of the technique, a prone postero anterior view with grid may be taken to determine any lateral displacement of the air filled stomach or tumour shadow in air relief.

Engel and *Lysholm* in a series of investigations of the normal, using 100 cm tube-film distance found that the average "pancreatic space" between the spinal and gastric shadows approximately equalled the width of the adjacent vertebral body. In enlargements of the pancreas this is widened, and the contours of the enlargement seen against the air filled stomach.

Of the two methods *Ticinini's* would appear to be the better, since it avoids the use of the Einhorn tube and since barium is a better contrast medium than air. In large tumours the Scandinavian technique might be used with barium as the medium instead of air.

Acute Haemorrhagic Pancreatitis—This is an abdominal catastrophe with a high mortality, and is rarely examined radiologically. It most commonly results from retrograde infection along the duct of Wirsung from biliary disease. The most severe types may die from collapse in twenty-four hours. If they survive the initial shock, abscess formation, haemorrhage into the pancreas, and fat necrosis are typical features.

Haring states that an antero posterior film may show blurring of the outer margin of the left psoas muscle in its upper part, from the enlarged gland, and also that the left dome of the diaphragm is immobile or nearly so. According to *Udvardy*, bilateral basal pleuritis and pneumomitis may occur from acute pancreatitis with abscess formation similar to that seen on the right side in subphrenic abscess. If a pancreatic abscess contains gas, it might be visible in a lateral supine view, which view may also show an enlarged pancreatic space, if the stomach contains air.

Chronic pancreatitis gives no localised radiological signs since it rarely, if ever, causes pancreatic enlargement. Steatorrhœa is sometimes a feature of this condition and may present a honeycomb or polypoid appearance in the colon after a barium enema (*Stenstrom*). Careful lavage before the examination will differentiate this appearance due to retained fat, from true polyposis of the colon.

Pancreatic Cysts—These are rare *Grey Turner* classifies them as follows

TRUE CYSTS

Acrinous—(1) Retention (2) Cystadenoma (3) Congenital cystic disease

Interacinarous—(1) Lymphatic (2) Parasitic

FALSE CYSTS

Intrapерitoneal—Inflammatory effusions into the lesser sac from injury or pancreatitis

Retropерitoneal—the result of breaking down of new growth or haemorrhage or abscess of the pancreas

TRUE CYSTS—The retention type is the commonest and usually results from obstruction from chronic pancreatitis. These cysts are commonly as large as an orange and may be enormous. Hydatids are rare in the pancreas but also may be of considerable size.

FALSE CYSTS—There are two types both of which may be large

(1) Loculated inflammatory effusions in the lesser sac in front of the pancreas

(2) Localised retroperitoneal effusion following the breaking up of the pancreas from old pancreatitis

RADIOLOGICAL FEATURES—A cyst if of some size may be visible in a plain postero anterior film. In a lateral view with stomach filled with air it produces a rounded forward bulge into the gastric lumen.

This pressure effect is also visible in a barium meal. A varying filling defect is produced in the stomach the size of the defect depending on the size of the cyst and the degree of filling of the stomach. Small cysts may produce no gap in the gastric shadow unless only a small amount of barium is present. The defect is then seen in the pars media centrally or towards and involving the lesser or greater curve depending on the exact site of the forward protruding mass. The defect fades away towards its margins and at the margins the mucosal folds are seen to be normal. *Koller* points out that the stomach if filled sufficiently to blot out the defect shows an apparent increased flexibility to the palpating hand during fluoroscopy. Very slight pressure is necessary to cause a gap in the barium shadow since only a thin layer separates the gastric walls at the site of the cyst. In a case seen by the writer the same effect was noted with the patient prone when the defect invisible with the patient standing appeared.

Large cysts may produce an extra-gastric defect which is not obliterated by complete barium filling, or may cause a marginal defect with lateral displacement of the stomach. A very large cyst may produce a gap extending right across the stomach. *Gersh* records such a case in which the cyst was also visible as a faint rounded opacity in a plain film.

A cyst near the head of the pancreas may cause a filling defect at the *meisura angularis*. One in the pancreatic head provides a deformity similar to that caused by carcinoma in that site.

Monauni has reported a case which showed first as a closed cyst, deforming the stomach. Later, after the cyst had ruptured into the stomach, a barium meal showed the cyst outlined with barium, and presenting three layers, of gas, pus, and barium.

Carcinoma of the Pancreas.—The common site for this is in the head of the pancreas, where it produces typical clinical and radiological features. The clinical picture is governed by the obstruction of the common bile duct with gradually increasing jaundice, distension of the gall bladder, and steatorrhœa.

RADILOGICALLY, the duodenum shows widening of its circle, narrowing of its lumen, and distortion of its shape. When the pancreatic enlargement is gross, the pyloric antrum may be raised and the duodenal flexure depressed (Fig. 247). Gastric stasis is a common result.

Pancreatic Calculi.—These are rare. According to *Köhler*, they are found in the ratio of 1 in 2,000 autopsies. They have to be differentiated from the upper abdominal calcifications, renal and biliary calculi and from calcified glands. They are commoner in males, and usually develop after the age of 30.

RADILOGICAL FEATURES.—Pancreatic calculi contain calcerum, and are therefore visible in a radiogram. They are nearly always multiple, and are scattered irregularly along the head and body of the gland. Their shape may be sleek-like, pointed, faceted, mulberry, or (rarely) round. *Haring* records an annular form.

In a radiogram the shadows of pancreatic calculi are usually disposed transversely or obliquely across the middle abdomen at about the level of the second lumbar vertebra.

Graham Holgson records a case of solitary calculus in the duet of Wirsung, diagnosed radiologically by combined cholecystographic and barium meal examinations. The former excluded gall stones, and the latter showed the opacity within the duodenal circle, close to the ampulla of Vater.



FIG. 247.—Carcinoma of the head of the pancreas producing elevation of the pyloric antrum and widening of the duodenal circle.

Cole records a case of calcification in a carcinoma of the head of the pancreas. S. A. Sennett records a case in which the calculi were large—up to 1 cm. in diameter—irregular in contour and scattered throughout the length of the pancreas. Their distribution made the diagnosis fairly definite.

THE SUPRARENAL GLANDS

Anatomy—The suprarenal glands are two small flattened bodies capping the upper poles of the kidneys. The right is more or less triangular in shape, the left lunate. They are about 1½–2 inches in length, rather less in width and 1–2 mm. thick. The posterior surfaces of both are in apposition to the diaphragm above and to the upper poles of the kidneys near the lower margins. The anterior surface of the right is related to the liver and inferior vena cava and that of the left to the stomach and pancreas.



FIG. 18. I RENAL INFLATION IN A CASE OF V.R.I. THE KIDNEYS ARE NORMAL; ADRENAL ENLARGEMENT IS EVIDENT.

Adrenal Tumours—These are rare and are usually diagnosed clinically or radiologically only when they have reached some size as in hypernephroma and neuroblastoma. They usually occur in children. Isolated cases of glioma, neuroma, fibromatoma, angioma, lipoma and cysts have been described.

The adrenal hypernephromas may be benign or malignant and are said to arise in the adrenal cortex (*Thomson & Haller*).

Large adrenal tumours may give evidence of their presence in a plain film (1) by their own shadow (2) by downward displacement of the renal shadow. Pyelography may show certain features. According to Cahill, Lock, Kurrok, Stont and Smith when the kidney is displaced downwards the upper pole is sometimes rotated inwards with the hilum facing downwards. In nephropathy and ectopia this rotation does not typically take place. If invasion of

The normal suprarenal glands are invisible in a plain radiogram but can be shown by the perirenal inflation method of Carelli (Fig. 24) or by pneumoperitoneum. When demonstrated by either of these methods they each present a characteristic outline.

The two conditions in which the radiologist's help may be sought are in tumours of the gland and in Addison's disease.



Fig. 249.—Calcified adrenal bodies in a case of Addison's disease



Fig. 240.—Calcification of the left suprarenal body in a case of Addison's disease

the upper pole of the kidney occurs distortion or obliteration of the upper calyces results in which case the differentiation from renal neoplasm may be difficult or impossible.

Three other methods of demonstration of adrenal tumours have been used with success. Perirenal inflation outlines the suprarenal capsule but is rarely used because of the technical difficulties. The technique is described in the section on the urinary tract. *Langeron* in 1929 demonstrated an adrenal tumour by pneumoperitoneum. The radiogram must be taken with the patient prone. *Roux Berger Naucler* and *Condiades* (1932) injected in one case 40 c.c. of thorotrast into the aorta and by thus outlining the arterial supply of the kidney, tumour and spleen were able to demonstrate the presence of a cortical adrenal tumour. It is a moot point whether exploratory laparotomy is not a more satisfactory procedure than this last.

Adreno-genital Syndrome—According to *Broster* this syndrome that of virilism is caused by either hyperplasia of the adrenal cortex or a cortical tumour both characterised by fuchsinophil cells. The syndrome may appear when the tumour is quite small and in these cases plain radiography is of no help. Perirenal inflation is then the only practicable method of X-ray demonstration.

Addison's Disease—When the tuberculous process in the adrenal gland has progressed to caseation and/or calcification the latter can be shown radiographically. *Ball Greene Camp* and *Rountree* out of twenty three consecutive cases successfully diagnosed six radiographically using a right oblique view for the left suprarenal and vice versa the tube being centred over the tip of the xiphisternum. This technique avoids the superimposition of the shadows of calcified costal cartilages.

From a combined study of films taken *in vivo* and of isolated post mortem specimens these authors classify the types of adrenal calcareous shadows as follows: (1) gross calcification of the entire gland; (2) discrete areas of calcification scattered throughout the gland (Fig. 249); (3) homogeneous increase in the opacity from the gland. The last is probably due to caseation. To the above three groups may be added that shown in Fig. 250 in which the calcification outlines the gland like an incomplete trabeculated shell.

I F Payne demonstrated caseation and calcification in three cases of Addison's disease, one of them associated with gross tuberculous caseo-calcification of the right kidney.

REFERENCES

- AIRIAT, J. *J. Radiol.* 1933 **XVII** 41
- BALL, R. G., GREENE, C. H. and COPE, T. D. *Amer. J. Roentgenol.* 1934 **XXI** 93
- BROSTER, I. R. *La* et 1934 **I** 831
- CARILLI, C. F. and OTHERS. *Surg. Gynec. Obstet.* 1936 **XIII** 287
- CARRELLI, H. H. and SORRELLI, F. *Ter. Soc. Met. Argent.* 1931 **XXXIV** 491
- COLE, I. G. *Met. Amer.* 1903 **XXXVI** 441

- ENGEL, A., and LYSHOLM, E., *Acta Radiol.*, 1934, XV, 635
FREELAND, K., *Röntgenpraxis*, 1933, VII, 368
GUTH, F., *Fortschr. geb. Ront.*, 1933, LI, 8
HARING, W., *Ergebnisse med. Strahlenforsch.*, 1933, VI, 497
HARRISON, B. J., "Textbook of Roentgenology," Baltimore, 1936
HODGSON, H. K., GRAHAM, *Brit J Radiol.*, 1932, V, 783
KADARAKA, S., and BARTANZ, L., *J. Radiol. Electrosl.*, 1934, XVIII, 161
KÖHLER, A., "Röntgenology," London, 1933
KOPPENSTADT, L., *Fortschr. geb. Ront.*, 1927, XXVI, 139
LANGEPOEN, L., and DANÉS, A., *Paris Med.*, 1929, II, 145
LOFFLER, W., *Münch. Med. Wochenschr.*, 1914, LXI, 763
MONAUNI, J., *Röntgenpraxis*, 1935, VII, 31
PAYNE, A. F., *Brit J Radiol.*, 1933, VI, 747
ROUX BERGER, J. L., NAGLEAU, J., and CONDEDEPS, X. J., *Bull. Soc. Natl. Chir.*, 1934, LX, 791
SEWELL, S. N., *Brit. Med. J.*, 1929, II, 1054
SHANDS, H. R., *Amer. J. Surg.*, 1933, XX, 707
SPITZ, L., *Röntgenpraxis*, 1932, IV, 993
STEVENSON, B., *Acta Radiol.*, 1935, XVI, 589
THOMSON WALKER, J. W., Choyce's "System of Surgery," London, 1932, II
TUKEY, G. GRAY, Choyce's "System of Surgery," London, 1932, II
UDVARDY, L., *Röntgenpraxis*, 1934, VI, 785
VOLICER, L., *Fortschr. geb. Ront.*, 1931, XLIV, 452

PART FOUR
FEMALE GENITAL TRACT

BY

R E ROBERTS, M D , B Sc , D P H , F F R , D M R E ,
AND
J ST GFORGE WILSON, M C , M Ch , F R C S

PART FOUR
FEMALE GENITAL TRACT
CHAPTER XXX
X RAYS IN GYNAECOLOGY

RADIOGRAPHY OF the female pelvic organs is employed as follows

- (1) Simple or "direct"
- (2) Combined with injection of some contrasting medium such as (i) Gas
- (ii) Opaque fluid (iii) Combination of (i) and (ii)

(1) DIRECT RADIOGRAPHY

The normal pelvic organs are not visible in ordinary direct radiograms. Under certain conditions, neoplasms of the uterus and ovaries cause shadows in X ray examination of the pelvis. The commonest neoplasm of the uterus is the *fibromyoma* which under ordinary conditions is of the same density as the surrounding tissues. Calcification of the fibroid, when it occurs, will render it opaque to X rays and may be found in one or two varieties—(a) homogeneously throughout the tumour, or (b) more commonly in patches throughout the tumour or on the surface. The opacity, of course, depends on the amount and the extent of calcification. Calcification of fibroids tends to occur as a rule, after the menopause, and does not usually of itself give rise to symptoms. *Calcified fibroids* (Fig. 251) are therefore usually diagnosed more or less accidentally by X rays in cases which are being examined either as a routine or on account of obscure symptoms. Calcification of fibroids is said to be a contraindication to X ray treatment, but from the foregoing it will be seen that, as these tumours do not give rise to the ordinary symptoms, their treatment by X ray therapy is not normally called for. Calcified fibroids are frequently found to be sub-serous and pedunculated in which case surgical treatment may be indicated as a result of torsion, intestinal adhesions, or obstruction.

One type of ovarian neoplasm, the *ovarian dermoid*, is noteworthy in that it contains calcareous and ossified tissue in varying amounts, which may in favourable cases give rise to shadows. Teeth are sometimes present, which may produce their characteristic X ray appearances.

Calciified plaques may also occur in walls of simple ovarian cysts, these are unlikely to be disclosed by X rays, owing to their small size and the thinness of the calcified tissue.

The relation of any doubtful opaque area in the pelvis to

ureters may be investigated by cystography or ureterography (intravenous or retrograde).

Whether the tumour contains opaque material or not, its relation to the uterus can be demonstrated by means of utero salpingography supplemented where necessary by pneumoperitoneum. A helpful procedure is that suggested



FIG. 21. Calcification in uterus. Film 1.

by *Becquerel* namely the preliminary demarcation of the limits of the palpable tumour by means of lead wire fixed to the skin so as to surround the tumour

INJECTION OF CONTRAST MEDIA

It was discovered that the injection of a gas into the peritoneal cavity made it possible to outline those organs which abut on that cavity and any neoplasms inside by the contrast of density between the tissues of the organ or neoplasm and the surrounding gas.

In women gas may be introduced into the peritoneal cavity via the uterus and Fallopian tubes or via the abdominal wall. The former method is commonly employed in the diagnosis of the patency of the tubes in the investigation and treatment of sterility but is contraindicated in cases of pregnancy and

in infections of the uterus and tubes, when the latter route may be used.

Air was the first gas to be used, but inasmuch as gas in the peritoneal cavity in any appreciable quantity gives rise to pain, and air is comparatively slowly absorbed (two to three days) it has been found that carbon dioxide gas is more satisfactory, being absorbed much more quickly (in a few hours).

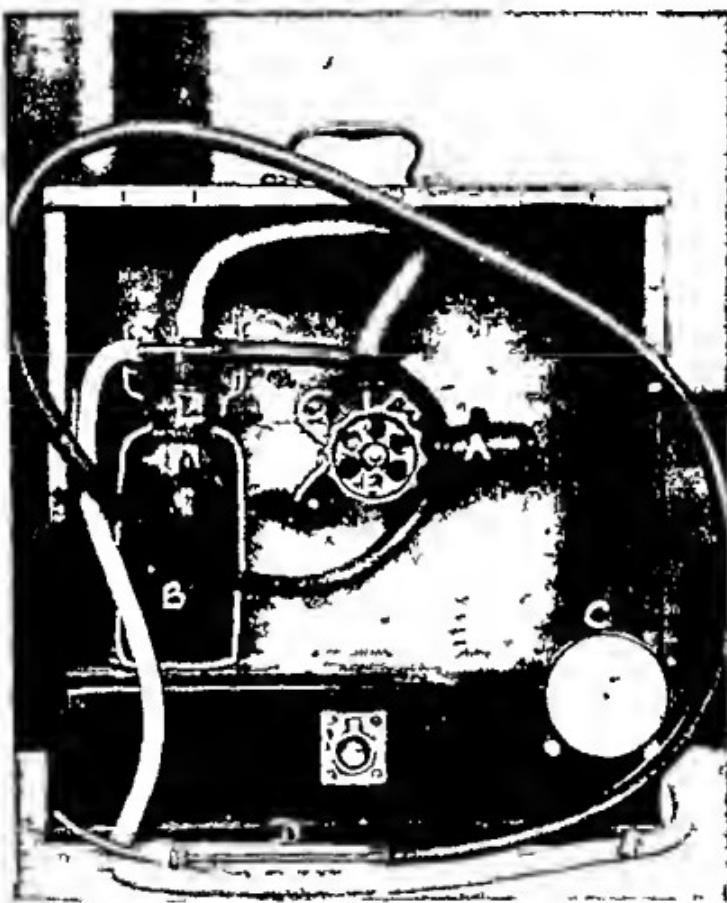


FIG. 22.—Provis apparatus. A Sparklet. B Bottle containing sterile warm water. C Manometer. D Rubin's cannula or hollow needle. E Control wheel.

Since Rubin first described the technique of transuterine inflation of the peritoneal cavity, numbers of different forms of apparatus have been described by various authors, using either air or carbon dioxide. Most authorities insist on measuring the pressure at which gas is passed through—the importance of which will be seen later—and others also introduce a flow meter in order to ascertain the quantity of gas introduced.

The apparatus described by Provis (Fig. 232) has been used both for

transuterine inflation by means of the uterine cannula, and for inflation through the abdominal wall by means of a hollow needle.

TRANSUTERINE INFLATION

This method is used almost entirely as a test of the patency of the Fallopian tubes, rather than as a means of inflating the peritoneal cavity.

Contraindications

- (1) The presence of an intrauterine pregnancy
- (2) Menstruation
- (3) Active infection of cervix or tubes
- (4) Ectopic gestation, hydrosalpinx or pyosalpinx

Careful bimanual examination should be made as a preliminary, preferably under anaesthesia. This examination is usually made before inflation, as a preliminary to dilatation of the cervix, which is the routine treatment of sterility. With ordinary antiseptic and aseptic precautions the procedure is practically harmless. In a certain small percentage it is followed by evidence of pelvic peritonitis and cellulitis, which is to be ascribed rather to the unrecognised presence of infection than to the recent introduction of sepsis by operative procedure.

The Technique — The writers use the apparatus designed by *Proust*.

This (Fig. 252) is prepared by placing a sparklet tube of CO₂ in the appropriate holder, by filling the bottle up to two thirds with warm sterile water, and by attaching the manometer and the cannula to the tubes leading from the T piece passing through the stopper of the bottle. The cannula is previously sterilised by boiling.

The vulva, vagina and cervix having been cleaned and painted with an antiseptic, the cervix is seized with volvulum forceps and drawn down to the introitus for inspection. A uterine sound is then passed to note the direction and length of the cavity of the uterus. The cannula is then passed till the olive is firmly pressed into the external os, in practice this is found to give a gas tight joint.

The stop-cock is then very carefully turned until it is seen that the gas is slowly passed through the bottle and into the cannula. This passage and its rate can be judged by watching the level of the gas bubble in the inner tube and the manometer.

It is imperative that the first passage of gas should be very slow, as the sudden raising of pressure in the uterus is said to give rise to spasms around the uterine ends of the Fallopian tubes (*Kennedy*), and may give a negative result to the test.

The reading of the gas pressure is watched on the manometer, and if the rise of the gas is sufficiently slow, it will be seen to rise very gradually until

it comes to a point when it ceases to rise, and remains stationary or even falls a few millimetres. This is taken as an indication of the passage of gas through the tubes. The rate of the passage of the gas through the apparatus is then slowly accelerated, maintenance of a steady pressure as recorded by the manometer at the previous or even a slightly higher level is regarded as confirmation of the passage of gas through the tubes.

If on the other hand the pressure shown on the manometer steadily rises up to 200 mm. of mercury the passage of gas is stopped at that level the pressure is allowed to fall again to zero and the procedure is repeated.

The raising of the intrauterine pressure to 200 mm. of mercury on two successive occasions without the escape of gas is taken to indicate that the Fallopian tubes are not permeable.

In those cases in which the manometric readings indicate the passage of gas, the latter is allowed to run through for a minute or two in order to collect sufficiently in the peritoneal cavity to give clinical and fluoroscopic X-ray signs. The same day (or the next day if the procedure has been carried out under general anaesthesia) an X-ray film of the diaphragmatic area is taken with the patient in an upright posture when the exhibition of gas as a translucent area under the diaphragm (i.e. between the diaphragm and the liver) establishes the diagnosis of patency of one or both Fallopian tubes. Where only a small amount of gas has entered the peritoneal cavity the translucent area may only appear as a thin triangle above the middle of the liver. Where a large amount has entered the diaphragm and liver may be seen separated by a wide translucent area extending transversely across the whole width of the abdomen (Fig. 203). The presence of even the smallest amount of free gas in the peritoneal cavity as seen between the diaphragm and liver is conclusive evidence of patency of one or both Fallopian tubes.

The absence of gas in this area is strong presumptive evidence of occlusion of both tubes. In such a case confirmation should be sought by injection of iodised oil into the uterine cavity (see uterosalpingography) as occasionally patency of one or both tubes may be demonstrated by uterosalpingography in a case where the findings by transuterine inflation were negative.

PERITONEAL GAS INFLATION THROUGH THE ABDOMINAL WALL

In gynaecological conditions this method may be employed in cases where it is undesirable to inflate *per uterum* particularly in pregnancy and in inflammatory conditions of the Fallopian tubes. It is of value sometimes in those cases where it is difficult to differentiate swellings of the tubes or ovaries from the uterus.

Technique.—There are certain technical difficulties to be overcome which are not present with the other method. The patient must be X-rayed in the Trendelenburg position in order to ensure that the gas in the peritoneal cavity flows into the pelvic cavity around the pelvic organs and that the intestines as

far as possible slide into the upper abdomen. This entails incorporating a Potter-Bucky diaphragm with a table capable of giving a good Trendelenburg position.

The patient requires careful preparation with regard to emptying the bowel and bladder the latter being attended to just before the procedure.

To inject the gas into the peritoneal cavity the Provis instrument is used.



Fig. 253. Free gas in peritoneal cavity between diaphragm and liver.

supplied with a sharp hollow needle at least 3 inches in length instead of the uterine cannula used in the transuterine inflation.

For the sake of comparison a film is taken of the patient in the Trendelenburg position before injection of gas.

The needle is inserted with antiseptic and aseptic precautions through the abdominal wall 1 inch below and 1 inch to the left of the umbilicus. Local anaesthesia to the skin is unnecessary. The most painful point is the passage of the needle through the peritoneum.

Before inserting the needle the gas is very slowly turned on to show 2-3 mm of mercury pressure. As the needle is pushed steadily through the abdominal wall the pressure is seen to rise a few millimetres and to fall rapidly again when the needle penetrates the peritoneum. This is not only a reliable indication of the entrance of the needle into the peritoneal cavity but will tend to prevent perforation of the intestines. Passing

the needle through the abdominal wall is safe and easy however without this manoeuvre.

After the initial perforation of the skin the needle is steadily pushed directly in and the overcoming of two slight resistances can be felt the first resistance being due to the anterior fascial sheath of the rectus muscle and the second to the posterior layer with which is incorporated (except in the very



FIG. 24.—Showing of enlarged uterus surrounded by translucent free gas in peritoneal cavity (Trendelenburg position).

obese) the peritoneum. When the point of the needle is in the peritoneal cavity the flow of gas is increased through it with due regard to the pressure recorded by the manometer which should not read more than 60 mm. pressure.

The writers have not used a flow meter being guided by the visible distension of the abdomen and by the sensations of the patient.

Films are then taken with the patient in the Trendelenburg position both prone and supine (Fig. 24).

Diagnostic Applications—In the diagnosis of pelvic conditions Jarcho states that the field for pneumoperitoneum is somewhat limited as it is generally reserved for cases in which pelvic infection exists or in which the Fallopian tubes are occluded making the production of pneumoperitoneum by the peruterine route unsafe or impossible. Under these conditions in obscure

cases, the injection of gas by puncture of the abdominal wall may prove of assistance in the diagnosis of *myomata fibroids, salpingitis, cystic and ovarian tumours* and in the location of *adhesions* involving the pelvic structures. It may thus clarify the situation before operation is undertaken and by accurately locating the lesion may limit and simplify the surgical procedure.

INJECTION OF OPAQUE FLUID (UTEROSALPINGOGRAPHY)

The injection of a fluid opaque to X rays followed the method devised by Rubin of inflation of the uterus and Fallopian tubes by gas. By many authorities it is claimed that it is superior to inflation with gas in that it shows

- (1) The outline of the uterine cavity
- (2) The length shape and disposition of the tubes
- (3) The patency of one or both tubes
- (4) If either tube is obstructed the site of obstruction
- (5) When used with an initial peritoneal inflation the relationship of the uterus and tubes to a neoplasm

Owing to the fact that when the tubes are patent, part of the fluid is retained in the peritoneal cavity it is necessary that the medium shall be non toxic. For this reason lipiodol or iodipin is used. These substances are opaque to X rays are non toxic and are gradually absorbed when retained in the tubes and peritoneal cavity without any ill effects.

If however the distal end of the tube be occluded or if the oil passes into a pocket or pockets due to peritoneal adhesions it may become encysted and be removable only by operative interference.

Contraindications—The same contraindications apply to uterosalpingography as are enumerated under transuterine inflation by air.

Technique—In this case it is necessary to make the injection of the fluid, viz. lipiodol, with the patient in the lithotomy position on the Potter Buck's table. The writers have not used any special apparatus beyond a 10 c.c. Record syringe fitted on the end of a Rubin's cannula. A special apparatus has been designed similar to that for injection of gas, by which the pressure as well as the volume may be estimated.

The patient's buttocks are brought to the end of the table, and a speculum is inserted into the vagina. The cervix is grasped with volvellum forceps and after swabbing a sound is inserted to give the length and direction of the cavity of the uterus. The cannula is then inserted and volsella are refixed to try to form a snug fluid tight joint between the cervix and the rubber acorn on the tube.

The patient is then moved back into position over the Potter Buck's diaphragm carefully without dislodging the tube in the uterus the legs being gently lowered so that the patient lies supine with the legs extended.

The film is then put in the carrier and all preparations are made for taking the radiogram before the injection is started. The writers have not made a

practice of watching the injection with a fluorescent screen but aim at taking the first radiogram when the cavity of the uterus is distended. The patient is specially warned not to move but to cry "Oh!" when she feels any pain. She has discomfort with the presence of the tube in the uterus, but as the oil is



FIG. 232.—Uterosalpingogram after injection of 4 c.c. lipiodol into uterus

slowly injected to fill the uterus it causes pain, and her cry is the signal to take the radiogram (Fig. 233) (or preferably a pair of stereoscopic radiograms). The amount necessary to achieve this varies in different subjects but is usually about 3-4 c.c.

The exposed film is removed and replaced by another one without removal of the cannula and a further film (Fig. 206) is taken after the injection of 1-2 c.c. more oil. Subsequent films may be taken to eliminate narrowing of the lumen of the tubes due to physiological contraction. (Leakage of oil back



FIG. 206.—Same patient as Fig. 205, after injection of 6 c.c. lipid oil into uterus.

through the cervix is very apt to occur and to spoil the pictures if the series of radiograms is not taken quickly.)

In the radiograms the outline of the uterine cavity is readily seen—that of the tubes depends on the conditions present.

Diagnostic Applications

—In the case of *normal tubes* (Fig 257) lipiodol is seen in the majority of cases to be present in small drops in the pouch of Douglas or in the neighbourhood of the fimbrial ends. In *occlusion of the fimbrial end* there may be shown a bulbous outline according to the condition of the tube with absence of drops in the peritoneal cavity. In *occlusion of the uterine end* there is, of course no lipiodol in the tube and consequently no shadow on the affected side (Fig 258). When the tubes become filled with lipiodol their shape, length and disposition are readily disclosed whether patent into the peritoneum or not.

It is strongly recommended that further films be taken after twenty-four and forty-eight hours in order to confirm in a positive case or substantiate or negative in a doubtful case the passage of oil through the tube. In the case of *patency of one or both tubes* the later radiograms will show the presence of lipiodol in streaks (Fig 259) resembling ripples of sand on the seashore in the cavity of the pelvis. This is caused by the lipiodol draining out of the tubes into the pelvis where it spreads out between



FIG. 257.—Uterosalpingogram. Normal Fallopian tubes.
Drops in pouch of Douglas.



FIG. 258.—Uterosalpingogram. Occlusion of both ends of both tubes.

the coils of bowel, that in the uterus drains out of the cervix into the vagina and is usually not seen in the later radiograms. Emphasis should be placed on the necessity for taking a radiogram on the day following the injection, as not infrequently lipiodol is then found in the peritoneal cavity (Fig 261) in cases in which from the earlier radiograms the tubes appear to be occluded (Fig 260). The non-passage of the lipiodol through the fimbriated



FIG. 261.—Uterosalpingogram. Same patient as Fig. 253. Radiogram 24 hours after injection of Lipiodol into uterus. Note wavy shadows of Lipiodol in peritoneal cavity.

ends of the Fallopian tubes at the time of the injection is presumably due to spasm which later relaxes and allows the lipiodol to pass into the peritoneal cavity giving rise to the characteristic wave-like shadows referred to.

Droplets of oil seen outside the tube indicate patency of the tube but if in the later radiograms (next day) they have failed to spread out to form the characteristic wave-like shadows indicative of free lipiodol in the peritoneal cavity the possibility of a walled-in peritoneal pocket must be



FIG. 260.—Apparently closed tubes. See radiogram taken next day.



FIG. 261.—Same patient as Fig. 260. Radiogram taken next day showing 1 prod. 1 in peritoneal cavity.

considered (Fig. 262). Droplets of oil inside a dilated tube will indicate the presence of *hydrosalpinx*.

The presence of a *bicornuate uterus* (Fig. 263) is readily demonstrated by uterosalpingography with iodised oil.

Inteflexion and *retroflexion* are best demonstrated in lateral radiograms after injection of iodised oil.

In the event of the uterine cavity showing a filling defect or defects the presence of *interstitial* or *submucous fibroids* or of *carcinoma uteri* is suggested.

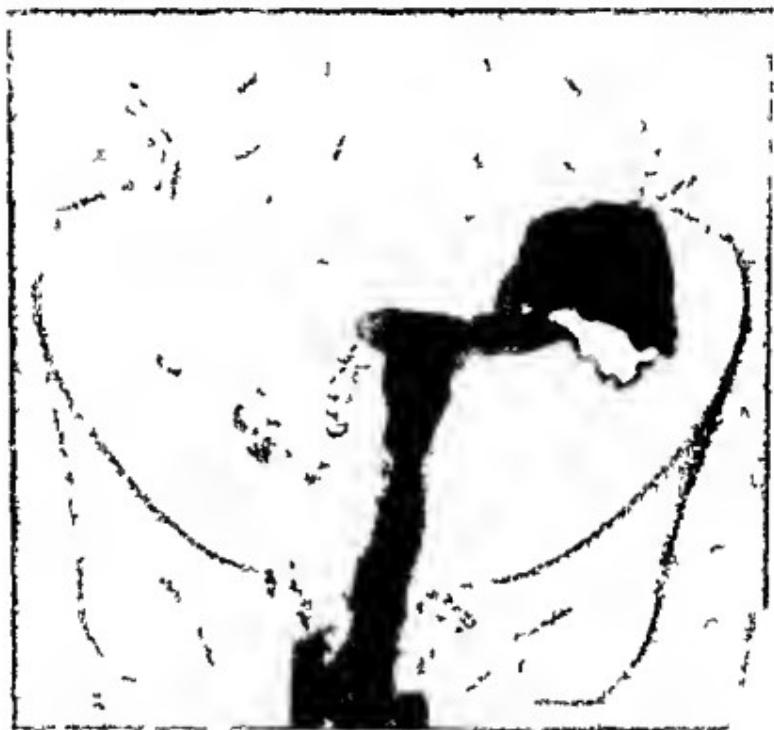


FIG. 262. Uterosalpingogram—oil in walled-in peritoneal pocket.

In the case of fibroids the filling-defect is usually smooth while in carcinoma it is more likely to be ragged in contour.

If a small polyp or submucous fibroid be present, especially on the anterior or posterior wall it may be obscured if the uterus be distended by lipiodol. For this reason a radiogram is advisable before the uterus is fully distended.

Where possible a control of the degree of filling is advisable by fluoroscopy, though the writers have not done this as a routine.

The differential diagnosis of an early pregnancy from a single fibroid is often

one of difficulty. According to *Hernstein* failure of the oil to enter the fallopian tubes in such a case is a point in favour of pregnancy. He states that early closure of the cornua is the rule in pregnancy irrespective of the site of attachment of the ovum.



Fig. 963.—Lateral salpingogram showing a uterus with two fallopian tubes. One tube is filled. Note filling defects due to submucous fibroids.

It should be noted however that fibroids in the region of the cornua may prevent filling of one or both tubes.

Where an *ectopic pregnancy* is suspected and the diagnosis cannot be established either by clinical means or by direct radiography, uterosalpingography may be of value. If it is found that both tubes are permeable ectopic pregnancy may be excluded. If one tube be permeable and the other dilated and

partly or completely obstructed, with a flat or rounded filling defect at the obstructed end, an *ectopic pregnancy* should be suspected.

In the case of extrauterine tumours, such as *ovarian* or *intraligamentous cysts* or *dermoids* or of *pedunculated fibromata*, the uterine shadow will show a displacement laterally or antero posteriorly away from the tumour, the shadow of the uterine cavity being otherwise normal. The Fallopian tube also will



FIG. 264.—Extrauterine tumour (ovarian cyst) causing displacement of the uterus and Fallopian tubes towards the opposite side. The palpable tumour limits are marked by a wire on the abdomen.

show elongation and displacement by the tumour (Fig. 264), over which it may be stretched.

If there is doubt as to the relationship to the uterus of a foetus shown by direct radiography, the question can be settled by demonstrating the position and shape of the uterine cavity by uterosalpingography. Such a procedure should not be adopted however, unless the termination of the pregnancy is in any case desirable (Fig. 265).

COMBINATION OF PERITONEAL INFLATION AND PER TUBAL INJECTION WITH LIPIODOL

The writers have no experience of this method. It is recommended by Stein and Arens particularly in cases of a tumour or tumours in the pelvis, in which it is required to differentiate the uterus and tubes.

The peritoneum must be inflated with gas first, the lipiodol is then injected and the film taken with the patient in the Trendelenburg position, as in a simple gas inflation.

According to Jarcho (who shows several illustrative radiograms) the combination of the two methods is indicated when additional information, not obtainable by either method alone, is desired. When successful, it enables the clinician to map out normal and abnormal states of the pelvic viscera. Frequently neoplasms of the uterus and adnexa are clearly demonstrated. The method also shows distinctly the sphincters at the proximal end of the interstitial portion of the Fallopian tubes.

Its maximum utility appears to be in the visualisation of *uterine fibroids* and of *ovarian cysts*, their relation to the uterine cavity being clearly demonstrated.

BIBLIOGRAPHY

- BECLÉPL, C., "L'Exploration Radiologique en Gynécologie," Paris, 1928.
- HEUSER, C., *Semana Med.*, 1924, II, 1496.
- JARCHO, J., "Gynaecological Roentgenology," *Annals of Paed.*, XXXI, 77, *Ibid.*, 179-90, *Ibid.*, 388.
- KENNEDY, W. T., *J. Amer. Med. Ass.*, 1923, LXXXV, 13.
- RUBIN, I. C., *J. Amer. Med. Ass.*, 1920, LXXIV, 1017.
- STEIN, I. F., and ARENS, R. A., *J. Amer. Med. Ass.*, 1926, LXXXVII, 1293.



FIG. 26.—Lipiodol injected into uterus. Angular pregnancy.

PART FIVE
OBSTETRICS

BY

R. E. ROBERTS, M.D., B.Sc., D.P.H., F.F.R., D.M.R.E.

PART FIVE
OBSTETRICS
CHAPTER XXXI
GENERAL TECHNIQUE

THE EVOLUTION of radiology in obstetrics has been comparatively slow. In earlier times workers were handicapped by limitations in the power of apparatus, it being impossible to produce currents of sufficient intensity and kilovoltage to penetrate satisfactorily the relatively opaque liquor amni and to cut down the length of the exposure to a degree in which the motility of the foetus and the respiratory movements of the mother could be eliminated. Nowadays however with apparatus having a large output of energy hot cathode tubes capable of carrying large currents the Potter Bucky diaphragm by which secondary radiations are largely eliminated immobilising appliances and ultra rapid films and intensifying screens the technical difficulties encountered by earlier workers have to a great extent disappeared. Satisfactory radiograms of the gravid uterus can now be obtained readily in from two to six seconds.

TECHNIQUE OF EXAMINATION

Even with the most efficient apparatus special attention must be paid to technique if uniformly satisfactory radiograms are to be obtained.

Apparatus and Accessories —A modern high tension transformer should be used with a hot cathode tube an efficient Potter Bucky diaphragm fitted with a compressor band and rapid speed double coated films and intensifying screens.

Kilovoltage —The quality of X rays used must be such that they will penetrate the opaque liquor amni but will not over penetrate the developing foetal bony parts. In the earlier stages of pregnancy and when the patient is thin and there is no excess of liquor amni a kilovoltage of 60 to 65 K V P will be sufficient. In the later stages of pregnancy or when the patient's girth is large (especially if this be due to hydramnios) kilovoltages up to 100 K V P may be necessary. A filter of 1-2 mm aluminium below the X ray tube is advisable.

Current —A current of 50 M A or upwards should be employed in order to cut down the time of exposure to a minimum.

Focus film Distance —If the distance between the target of the X ray tube and the film be small the exposure will be cut down but owing to the divergence of the rays there will be produced on the film a lack of definition and a disproportion between the foetal and maternal parts which may be misleading.

If the focus-film distance be great the disproportion will be less but the time of exposure will need to be increased to a degree when foetal and maternal movements may occur with resultant blurring of the image.

A routine working distance of 30 inches between the target and film is therefore recommended as a satisfactory compromise. Whatever working distance be decided upon it is advisable to keep it constant for all cases in order that the resultant radiographic sizes may be comparable.

Exposure—This will depend on the milliamperage used, the speed of the films and intensifying screens and the distance of the tube from the film together with the thickness of the part to be radiographed.

The shorter the exposure the less risk is there of the film being spoilt by foetal or maternal movements. With suitable apparatus and accessories satisfactory radiograms at a focus-film distance of 30 inches should be obtained in a patient of moderate size in about two seconds—in no case should the exposure exceed six seconds—otherwise blurring of the foetal or maternal movement is practically inevitable (this does not of course apply to pelvimetry where the foetal image is of secondary importance).

Position of Patient—It is usually advisable to take radiograms in the supine, prone and lateral positions (right or left according to the position of the fetus). Occasionally an oblique view is advisable to throw the shadow of the foetal bony parts away from the maternal skeletal shadows.

In the prone position it may be desirable in some cases to relieve the pressure on the abdomen by supporting the thighs on a pillow if necessary also the patient may be allowed to rest the thorax firmly on the elbows with the arms crossed under the chest but out of the way of the abdomen. The chief advantages of the prone position are that this position in most cases brings the fetus nearer the film and also immobilises it better resulting in clearer definition of the foetal parts.

The advantages of the lateral view are that it gives information relating to the position of the foetal spine (anterior or posterior) and that the foetal limb shadows are more likely to be shown clear of those of the maternal spine. On this account ossific centres in the fetus can often be shown more readily in this position than in the prone or supine position. Lateral radiograms in the erect position are of special value in patients with pendulous abdomens where information is required regarding the inclination of the pelvic brim to the axis of the lumbar spine—in such examinations a vertical Potter-Bucky diaphragm is of course required.

The lateral view centred over the brim of the pelvis also gives valuable information as to the plane of the brim, the lumbosacral angle, the shape and plane of the anterior surface of the sacrum, the inclination of the posterior surface of the symphysis pubis and the relation of the foetal head to the superior strait of the pelvis. It also gives a ready means of confirming the measurement of the conjugate diameter of the brim as estimated by other pelvimetric methods (see later).

In the supine position especially if there be lordosis it is often helpful to put a pillow beneath the knees of the patient this gives a greater sense of comfort to the mother and brings her spine nearer to the film by flattening out the lumbar curve

Immobilisation of the Fœtus—This is helped by the use of a compressor band the latter should however not be pulled too tightly otherwise increased foetal activity instead of immobilisation will be the result

Suppression of Maternal Respiratory Movement—Owing to the presence in the abdomen of the enlarged uterus the pregnant woman finds it more difficult to hold her breath than the non pregnant patient It is however essential that during the exposure there shall be no respiratory movement The readiest means of bringing this about is to make the patient after a few preliminary respirations hold her nose and close her lips at the point of deep expiration After a little practice most patients can by this means be persuaded to suppress their respiration for the requisite period of time during the making of the exposure Obviously the shorter the exposure the better the result in this respect Experience shows that there is a better chance of complete immobility on the part of the diaphragm in expiration than in inspiration

A series of at least three radiograms (supine prone and lateral) now having been taken our next consideration is the information that may be obtained from them

INFORMATION AVAILABLE FROM RADIOGRAPHIC EXAMINATION

Information on the following points may be available from an inspection of the radiograms

- (1) The positive diagnosis of pregnancy or in a case of an obscure swelling the differential diagnosis between pregnancy and a pelvic tumour
- (2) The presence or absence of any gross maternal deformity (lesser degrees of deformity are demonstrable by means of radiological pelvimetry to be described later)
- (3) The approximate indication of the age of the fœtus
- (4) The position and presentation of the fœtus the position of its limbs and the degree of flexion of its spine and head
- (5) The existence or otherwise of any disproportion between the foetal head and the maternal pelvis
- (6) The cause of hydramnios with special reference to multiple pregnancy and foetal abnormalities
- (7) Intrauterine death of the fœtus
- (8) Occasionally evidence of extrauterine pregnancy

CHAPTER XXXII

DIAGNOSIS OF PREGNANCY AND MATERNAL PELVIC DEFORMITIES

X-RAY DIAGNOSIS OF PREGNANCY

Since the advent of the Zondek Ascheim test the early diagnosis of pregnancy by radiology is of less importance than previously.

The radiological diagnosis is however an immediate one, whereas the Zondek Ascheim test takes a few days for its completion. The radiological examination is particularly applicable in cases of suspected illegitimate pregnancy where obvious difficulties may arise in performing a clinical examination.

Diagnosis by Direct Radiography—Owing to the relatively poor calcium content of the foetal skeleton in the early stages of pregnancy, it is not possible, even with the most careful technique to demonstrate foetal bony parts before the thirteenth week. As a rule consistent demonstration of foetal parts is not possible till about the sixteenth to twentieth week. The film must be of good quality and the shadows of the maternal bony parts dislodged from the uterine area as much as possible. For this purpose the prone position may be used with the tube tilted slightly towards the head or the supine position with the tube tilted slightly towards the feet. Sometimes a slightly oblique position of the mother's pelvis in relation to the central ray is also of advantage.

In the pelvic area the shadows to be searched for are one or more of the following (Figs. 266, 267).

- (a) The crescentic or annular shadows of the foetal skull
- (b) The beaded shadow of the foetal spine
- (c) The ladder-like shadow of the foetal ribs
- (d) The linear shadow of one or more of the foetal limb bones

Before excluding the presence of a foetus at least three good radiograms should give negative results. In cases of doubt the examination should be repeated after an interval of one or two weeks. Care should of course, be taken to eliminate rectal or vesical shadows by efficient preliminary preparation.

At or after the sixteenth week it should be possible to exclude pregnancy definitely by radiographic means. The differential diagnosis of pregnancy from *hydatidiform mole*, *uterine* or *other pelvic tumours* should be thus rendered definite.

Diagnosis by the Use of Contrast Media—By injecting lipiodol into the uterine cavity Heuser had been able to demonstrate as early as one week after conception the presence of the ovum as a filling defect in the opaque medium. The employment of this method however is indicated only in cases where a

termination of pregnancy if present would be desirable there is a grave risk of the oil, when injected into the uterine cavity producing abortion. A submucous polyp if present might produce a filling-defect which would be indistinguishable from that of an ovum.

By the method of transabdominal pneumoperitoneum Peterson has been able



FIG. 966.—Thirteen weeks' fetus showing limb bones, spine and ribs.

to diagnose uterine enlargement indicative of pregnancy as early as the sixth week.

However *Hernstein* states that in cases of pregnancy the cornua close early so that a rounded filling defect in the uterine cavity combined with non-filling of the Fallopian tubes is presumptive evidence of pregnancy rather than of fibroids (see p. 377).

Albano claims to have demonstrated by intravenous injection of 2 grms. of strontium bromide in a 10 per cent solution half an hour before radiography, a two months pregnancy as a relatively translucent area in the liquor amni (which has been made more opaque by excretion of the dye). He also claims to be able to differentiate between pregnancy and a uterine fibroid by this

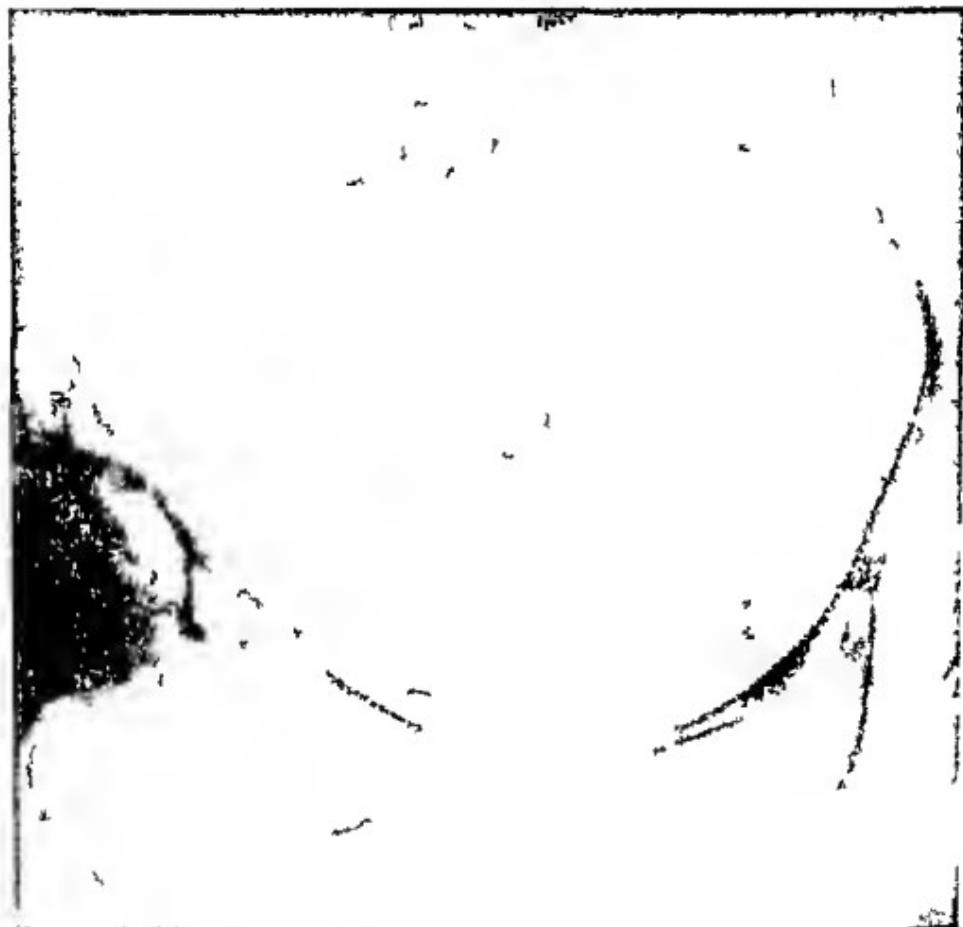


FIG. "G" — Six weeks' gest. + w.m. skull ribs and limb bones

method the uterus in pregnancy showing a clear-cut outline as opposed to the fluffy shadow of fibroids. His work however lacks confirmation

CHANGES IN THE PELVIC JOINTS DURING PREGNANCY

During pregnancy the symphysis pubis and to a less extent the sacroiliac joints increase in width. By applying the appropriate correction factors

to compensate for the distance of these joints from the film Roberts estimated the true width of the symphysis pubis and sacro iliac joints in the series pregnant and non pregnant women. He found the average "mean" width of the symphysis pubis in nulliparous women to be 26 mm, during pregnancy this increased to 45 mm. During parturition he found that any further increase in width was very slight and that within a few months after parturition the width usually returned to its pre pregnant measurement. In multiparous women the increase in width during pregnancy was slightly greater than primigravidae, the average width in pregnant multiparae being 5 mm



FIG. 269.—Dislocation of symphysis pubis following difficult labour.

opposed to the primigravidous average width of 45 mm. The maximum width seen in his series was 10 mm.

In pregnant cases with a wide symphysis he was able to demonstrate radiologically a vertical or gliding movement of the pubic bones on each other when the weight of the body was transferred from one foot to the other.

The sacro iliac joint likewise widens slightly during pregnancy. The average aggregate width of the two sacro iliac joints in nulliparous women was found to be 36 mm. In primigravidae it increased to 45 mm, while the same measurement was recorded for multiparae. After parturition the average width of the joints was found to return to 39 mm, i.e. almost, but not quite, to its pre pregnant width.

As a result of difficult labour with or without the application of forceps traumatic rupture or dislocation of the symphysis pubis sometimes occurs (Fig. 268). Occasionally fractures through the pubic and ischial rami may occur.

Normally however the foetal skull gives way to the pressure more readily than the firmer maternal bony pelvis with the result that radiograms taken during parturition show a greater or less degree of moulding of the bones of the vault which may override each other to a marked degree (Fig. 302).

MATERNAL PELVIC DEFORMITIES

Gross pelvic deformities will be usually demonstrated in a single radiogram in the supine position amplified where necessary by stereoscopic radiograms in either the supine or prone position and/or by a lateral view. Minor deformities however may need a more accurate investigation by means of radiological pelvimetry.

Any deformity of the maternal spine or pelvis which may give rise to difficult labour is of importance to the obstetrical radiologist. As however the X-ray appearances associated with the various conditions which may result in such deformities have been described elsewhere in this book no useful purpose will be served by their reiteration. It may however be of service to the radiologist if their obstetrical classification be recalled at this juncture. The following classification by *Schauma* modified by *Dougal* will probably be found the most suitable.

A CONGENITAL ABNORMALITIES

- (a) Generally constricted pelvis
- (b) Simple flat pelvis
- (c) Assimilation pelvis
- (d) Negele pelvis
- (e) Roberts pelvis
- (f) Generally enlarged pelvis
- (g) Split pelvis

B ACQUIRED ABNORMALITIES

(1) Disease or Injury of the Pelvic Bones

- (a) Rickets
 - (i) Rachitic flat pelvis
 - (ii) Rachitic flat and generally constricted pelvis
 - (iii) Irregularly constricted rachitic pelvis
- (b) Osteomalacia—osteomalacic pelvis
- (c) New growths
- (d) Fracture
- (e) Atrophic caries necrosis

(2) *Disease or Injury of the Pelvic Joints*

- (a) Synostosis of the pelvic symphysis
- (b) Synostosis of one or both sacro iliac joints
- (c) Synostosis of sacro coccygeal joint
- (d) Exaggerated movement or separation of pelvic joints

(3) *Disease or Injury of the Vertebrae*

- (a) Scoliosis
- (b) Kyphosis
- (c) Hypo scoliosis
- (d) Lordosis
- (e) Spondylolisthesis

(4) *Disease or Injury of the Hip Joints or Lower Limbs*

- (a) Coxitis
- (b) Luxation of the head of one or both femora
- (c) Absence or deformity of one or both lower extremities

CHAPTER XXIII

RADIOLOGICAL PELVIMETRY

WHILST CORDIALLY agreeing with the axiom that the best pelvimeter is the foetal head one finds that obstetricians are not infrequently faced with cases in which the relative size of the foetal head and of the pelvic inlet cannot be gauged by clinical means. In such cases radiology may be called on to play an important part in accurately assessing the diameters of the pelvic brim or of the outlet.

It is obvious that the less tissue the X rays have to penetrate (i.e. the earlier in the pregnancy) the clearer will be the radiograms. Unfortunately the patient is often allowed to go almost to full term before the radiologist is asked to investigate her pelvic measurements.

RADIOLOGICAL PELVIMETRY OF THE INLET

Among the methods more commonly employed in this country for estimating the diameters of the brim by radiological means may be mentioned the following:

Methods of Thoms, Roberts and Rowden—In each of these methods the brim of the pelvis is placed horizontally and parallel to the X ray film and the central X ray is made to pass vertically through its centre. The radiogram so obtained is a symmetrically enlarged picture of the pelvic brim (Fig. 269) without any of the foreshortening seen in the usual supine or prone radiograms.

Technique of Thoms' Method of Pelvimetry—The patient is placed in the sitting position (originally described by *Albert*) on the middle of the Potter Buckly diaphragm her shoulders being supported by an adjustable back rest. The patient and back rest are manipulated till the pelvic brim is horizontal i.e. parallel to the film on the Potter Buckly tray. This is attained by means of a calliper one foot of which is placed in contact with the upper border of the symphysis pubis while the other foot is placed in contact with the lower border of the spine of the fourth lumbar vertebra (the latter point is situated about an inch above the line joining the posterior superior spines of the iliac bones felt in dimples on each side of the middle line).

The patient having been placed centrally over the film in this position and leaning firmly against the back rest (which will be about 55° 60° from the horizontal) the X ray tube is placed so that its focal spot is vertically above the middle of the pelvic brim (approximately 2 inches behind the upper border

of the symphysis pubis). The tube is then raised or lowered till its target is 30 inches vertically above the film.

The radiogram is now taken and the vertical height of the upper border of the symphysis (corresponding to the horizontal plane of the pelvic brim) is measured. The patient is now removed from the table the tube and film being left in position.

A perforated metal sheet (in which small holes have been punched at the points of intersection of lines drawn at right angles 1 cm apart) is now substituted at the height previously occupied by the patient's pelvic brim and a

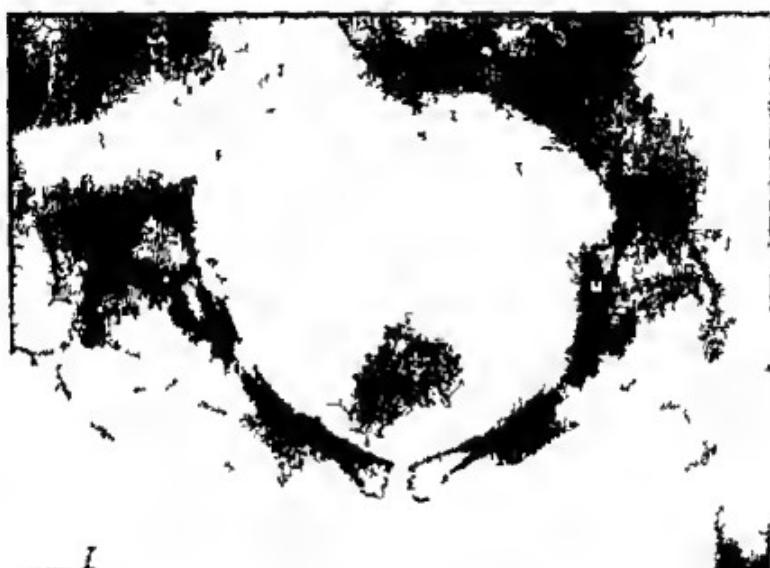


FIG. 269.—Radiogram in sitting position with pelvic brim placed horizontally.

short exposure of one to two seconds is made. The perforations in the metal sheet show on the film as black dots; these dots on the film are slightly more than 1 cm apart according to the height of the sheet above the film. The length of the diameters can now be measured directly on the film (in centimetres) from this false centimetre scale produced by the dots.

Technique of Roberts' Method of Pelvometry—In this method the position of the patient tube and film are as in Thoms' method (i.e. the patient sits on the Potter Bucky diaphragm with the pelvic brim horizontal her back being supported by an adjustable back rest and her head kept extended so as to be at a safe distance from the tube the tube being rotated so that its projecting arms are across the long axis of the table. The tube is centred 30 inches vertically above the centre of the brim (2 inches behind the vertical plane of the symphysis—estimated more accurately, if desired, by means of a plumb

bob—hanging down beneath the centre of the filter in the diaphragm of the tube box) (Fig. 270)

The radiogram is now taken, an exposure of five to twelve seconds is usually sufficient with an efficient apparatus (10 K V.A. transformer, hot-cathode tube passing 50 M A at 100 to 120 K V P), this exposure may need to be increased in a bulky or advancedly pregnant patient.

A radiogram of more even density is obtained if the "hatchet" described

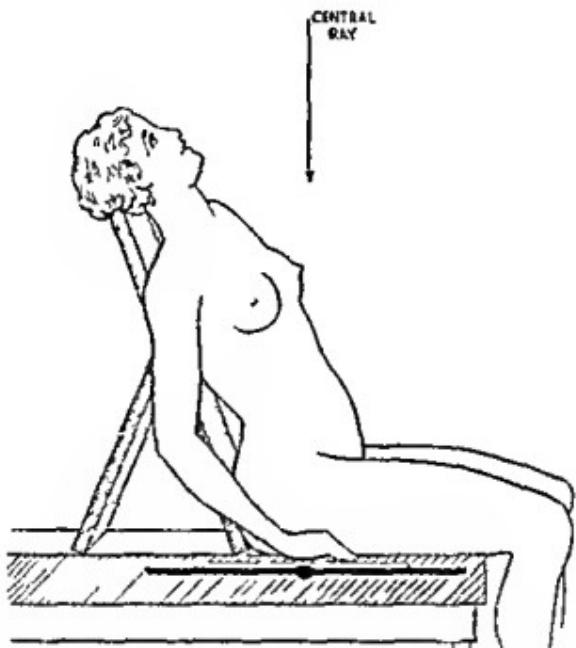


FIG. 270.—Position of patient in Roberts' method of radiological pelvometry. By this means the pelvic brim is brought parallel to the film and an undistorted, uniformly enlarged representation of the brim is obtained. From the radiogram all the diameters may be readily and accurately estimated.

in Roeden's method (see later) is employed, this prevents the relative over-exposure of the anterior portion of the brim which otherwise takes place.

Immediately after the radiogram has been taken and without moving the patient the following measurements are made:

(1) The vertical height of the antecathode above the upper border of the symphysis pubis (by a tape measure) or alternatively the vertical height of the top of the symphysis above the film (by ruler).

(Instead of measuring the tube-symphysis distance it will probably be found easier to measure the symphysis-film height. The simplest way of doing this is to use an ordinary wooden ruler from the bottom of which a

length has been chopped off equal to the vertical distance between the surface of the middle of the Potter Bucky table and the film. This distance is readily measured by placing a strong lath transversely across the top of the table and measuring the vertical height of this above the middle of the table and above the film respectively, the difference between these two measurements is the distance between the film and the top of the table and is the amount which must be chopped off from the end of the ruler. It must be measured accurately, otherwise an error will be introduced into all future estimates of pelvic measurements based on this technique. In the curved topped Potter Bucky table used by the author it is $1\frac{1}{2}$ inches. It will vary with different tables and different types of cassettes.)

(2) The vertical height of the anticathode above the film (a standard tube film height of 30 inches is suitable, with suitable apparatus this may with advantage be increased to 40 inches)

It is easy to estimate the true diameters of the pelvic brim from those on the film by employing the geometric principle illustrated in Fig. 271.

To obviate the necessity for these geometrical calculations tables have been prepared from which one can obtain at a glance the corrected or true measurement of any diameter from the corresponding film measurement (Tables 1 and 2).

Thus if when using the 30 inch tube film distance the tube symphysis height be $24\frac{1}{2}$ inches (*i.e.* symphysis film height $5\frac{1}{2}$ inches) and the measurement on the film of the transverse diameter be say $6\frac{1}{4}$ inches, then the true measurement of the transverse diameter is seen from the table to be $5\frac{1}{2}$ inches. Similarly for any other measurement.

Similar tables may be prepared for any tube film distance other than the standards used here. Obviously, the greater the tube film distance, the smaller the margin of error. Many workers are, however, limited in their working distance, either by the output of their plant or by the type of Potter-Bucky table available.

Estimation of the Measurement of the Conjugate from Lateral View of Pelvis—In the event of a patient having spinal or hip disease, it may be impossible so to posture the patient that the conjugate is parallel to the film, or



FIG. 271

A = target of tube
 DE = required diameter of pelvic brim
 FG = corresponding diameter of brim as measured on film
 AB = height of tube above symphysis pubis
 AC = height of tube above film

$$\frac{DE}{FG} = \frac{AB}{AC}$$

$$DE = FG \times \frac{AB}{AC}$$

i.e. True diameter = film diameter multiplied by correction factor $\left(\frac{AB}{AC}\right)$

RADIOLOGICAL PELVIMETRY CORRECTION TABLES

TABLE I—WHERE TUBE FILM HEIGHT = 30 INCHES

Measurement on Film	True or Corrected Measurement.			
4 inches	3.2	3.3	3.3	3.4 inches
4 1/2	3.4	3.5	3.5	3.6
4 1/4	3.6	3.7	3.7	3.8
4 3/4	3.8	3.9	3.9	4.0
5	4.0	4.1	4.1	4.2
5 1/2	4.2	4.3	4.4	4.5
5 1/4	4.4	4.5	4.6	4.7
5 3/4	4.6	4.7	4.8	4.9
6	4.8	4.9	5.0	5.1
6 1/2	5.0	5.1	5.2	5.3
6 1/4	5.2	5.3	5.4	5.5
6 3/4	5.4	5.5	5.6	5.7
Tube symphysis height (inches)	24	24 1/2	25	25 1/2
Symphysis film height (inches)	6	5 1/2	5	4 1/2

TABLE 2—WHERE TUBE FILM HEIGHT = 40 INCHES

Measurement on Film	True or Corrected Measurement			
4 inches	3.4	3.4	3.5	3.5 inches
4 1/2	3.6	3.7	3.7	3.7
4 1/4	3.8	3.9	4.0	4.0
4 3/4	4.0	4.1	4.2	4.2
5	4.2	4.3	4.4	4.4
5 1/2	4.5	4.6	4.6	4.7
5 1/4	4.7	4.7	4.8	4.9
5 3/4	4.9	4.9	5.0	5.1
6	5.1	5.2	5.2	5.3
6 1/2	5.3	5.4	5.5	5.5
6 1/4	5.5	5.6	5.7	5.8
6 3/4	5.7	5.8	5.9	6.0
Tube symphysis height (inches)	34	34 1/2	35	35 1/2
Symphysis film height (inches)	6	5 1/2	5	4 1/2

in an obese or otherwise unsatisfactory patient it may be desirable to confirm the conjugate measurement as estimated by the foregoing method. In cases of pendulous abdomen or when the fetal head overrides the symphysis pubis it may be difficult to measure the exact height of the symphysis above the film or below the tube.

In such cases the measurement of the conjugate can be readily estimated from a lateral view of the pelvis. The patient is placed lying accurately on

the side so that the conjugate diameter is horizontal (i.e. symphysis pubis at the same height as the natal cleft or more accurately the spinous process of the fourth lumbar vertebra).

The tube is centred vertically over the upper border of the greater trochanter at a height of 40 inches above the film. The radiogram is taken and the vertical distance between the symphysis pubis and the target of the tube is measured (by a tape measure or ruler).

The conjugate diameter (distance between the posterior surface of the upper part of the symphysis and the anterior surface of the promontory) is measured on the film. From this it is quite easy to estimate the true conjugate by employing the principle of Fig. 271.

Technique of Rowden's Method of Pelvimetry

In this the patient is placed in the same position in relation to the film as in *Thoms'* and *Roberts'* method (*Albert's* position) and the tube again centred vertically above the middle of the horizontally placed pelvic brim. The tube-film distance is however, greater than in *Thoms'* and *Roberts'* methods, being 4 feet 6 inches, and a Sectogrid Potter Bucky diaphragm takes the place of the curved type. The increased tube-film distance diminishes the degree of distortion produced on the film.

To prevent relative over-exposure of the anterior portion of the brim or under-exposure of its posterior portion *Rowden* advocates the use of a "hatchet". This is a sheet of lead on a wooden handle, the whole resembling a spade with the distal portion cut out into a slight concavity. After the anterior portion of the brim has received about twelve seconds' exposure (15 M A at 120 K V P) this hatchet is placed horizontally against the patient's abdomen about the level of the umbilicus, the exposure of the posterior portion of the brim is continued for a further twelve to thirty seconds (according to the size of the patient's abdomen). By this means the resultant radiogram is rendered of more even density.

In measuring the diameters, *Rowden* uses the appropriate one of a series of "pubic scales", these are prepared as follows:

A strip of lead, called a "rule," is used, about 12 inches long and 2 inches wide, supported by plywood, the lead strip has small holes drilled down the centre exactly half an inch apart.

From this "rule" the "pubic scales" (Fig. 272) are made in the following way. The "rule" is supported horizontally over the Potter Bucky couch 4½ inches above the surface, a film in a cassette being placed in the usual position. The X-ray tube is centred 4 feet 6 inches above the film and a short exposure, about a second, given. The "rule" is then raised a quarter of an inch and another exposure is made on another film, and so on every quarter of an inch up to 6 inches. The films are developed and a number of prints are made from each for stock, and each has its distinctive figure of height marked on it. The



FIG. 372.—Rowden's pulse scale.

films are taken with the tube centred $1\frac{1}{2}$ inches above the os pubis and just above the great trochanter respectively.

The thickness of the patient from pubis to couch (*a*) and her extreme width across the trochanters (*b*) are then measured. Let the focus-film distance be 28 inches (*c*). On the antero-posterior film the transverse diameter is measured (*d*) and on the lateral film the distance from the sacral promontory to the back of the os pubis (*e*).

The calculation is as follows:

$$\frac{d \times (r - \frac{2}{3}a)}{c} = \text{true transverse diameter}$$

$$\epsilon = \frac{(c - \frac{1}{2}b)}{c} = \text{true conjugate diameter}$$

Technique of Courtney Gage's Method of Pelvimetry

In Courtney Gage's method the patient occupies the semi-sitting position over the film the tube being centred over the middle of the pelvic inlet a plumb bob hanging from the centre of the filter and remaining in position during the exposure.

spots on the scales thus produced represent half inches at horizontal planes above the surface of the Bucky couch.

Technique of Hooton's Method of Pelvimetry

In Hooton's method antero posterior and lateral

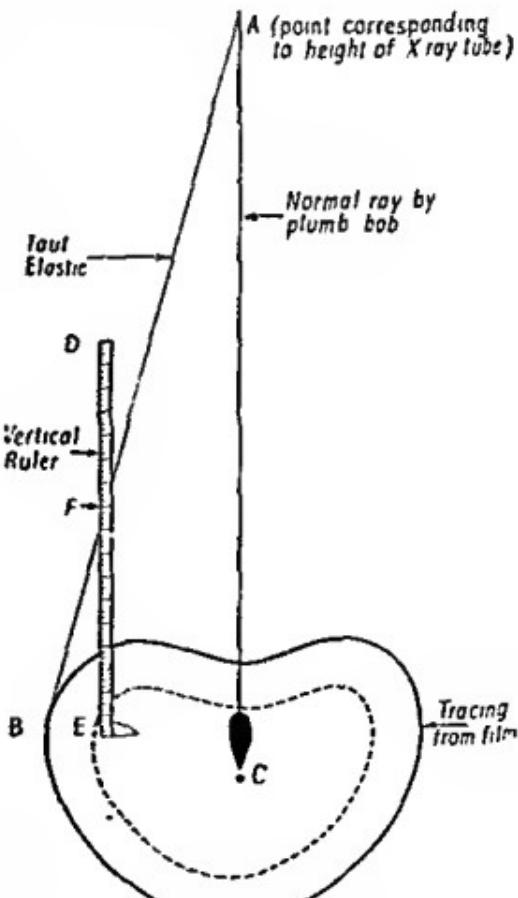


Fig. 273.—Illustrating Courtney Gage's method of polarimetry.

of the film, thus records on the film the point of incidence of the normal or vertical ray.

The distances of the tube and of the top of the symphysis pubis from the film are measured.

After development, a tracing of the outline of the pelvic inlet is made from the dried radiogram, and a dot placed on the tracing at a point corresponding to the centre of the shadow of the plumb bob. This tracing is pinned on to the table.

By means of a taut piece of elastic (AB) a plumb bob (AC) and a vertical ruler (DE), used as in the illustration (Fig. 273), the lines of the rays which have produced the image of the pelvic brim are reproduced, the lower end (B) of the elastic being moved round the tracing and the ruler being moved till the point on it (F) corresponding to the height of the symphysis pubis above the film intersects the elastic.

By marking with a pencil dots on the tracing at points corresponding to the base of the ruler (E) and joining these dots an exact reproduction of the pelvic brim is obtained from which the various diameters are measured directly.

RADIOLOGICAL MEASUREMENT OF THE PELVIC OUTLET

Transverse Diameter Chassard and Lapine's Method

The patient is placed straddling a cassette containing a $12'' \times 10''$ film, she is made to stoop forward till the under surface of the symphysis pubis and the ischial tuberosities are equidistant from the film; i.e. the pubic arch is now horizontal. The tube is centred vertically above or slightly posterior to the ischial tuberosities at a distance of 30 inches or more from the film (Fig. 274).

A radiogram is now taken (about one to one and a half seconds will suffice with 30 mA at 75 KVP). On the radiogram (Fig. 275) a horizontal line is drawn to touch the surfaces of the ischial



FIG. 274.—Position of patient, film and tube in Chassard and Lapine's method of pelvimetry of outlet.

tuberousities. A vertical line is drawn from the symphysis pubis to bisect this. A second horizontal line is now drawn 1 cm nearer the symphysis pubis than the first one (to compensate for enlargement due to distance of bony parts from the film). The length of this line is approximately the measurement of the transverse diameter of the outlet (normally 4 inches).

From this radiogram there can also be determined by direct measurement:

(1) The angle of the pubic arch (normally 83°)

(2) The height or depth of the pubic arch (normally about 2½ inches)

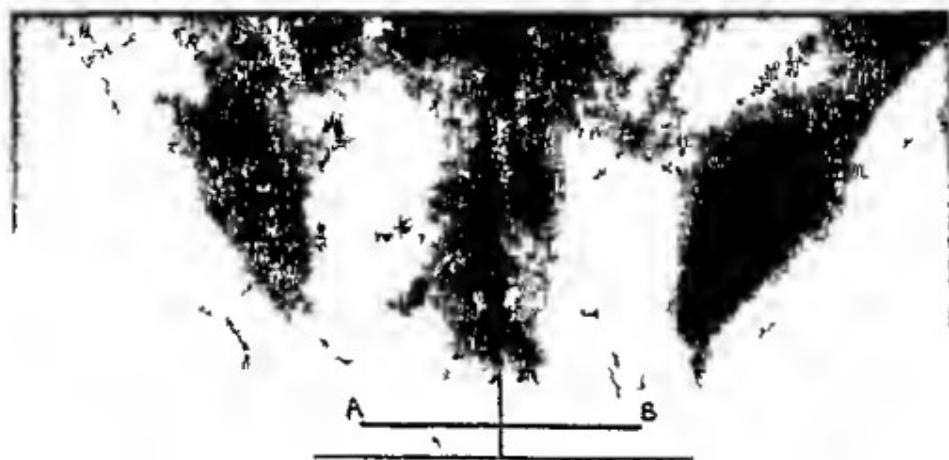


FIG. 275.—Radiogram of pelvis outlet by Chassard and Laprade in the I.A.R. = transverse diameter of outlet (see text).

Antero-posterior Diameter of the Outlet (Posterior Portion)

Any forward tilting of the sacrum or coccyx will diminish the antero-posterior diameter of the outlet.

Technique—On the Potter-Bucky diaphragm the patient lies on her side and the tube is centred vertically above the ischial tuberosities (the position of the patient being adjusted till these are above the centre of the film). A radiogram is now taken.

The vertical distance of the tube from the film and from the natal cleft is measured by a tape measure and the appropriate correction factor is estimated. The film measurement of the distance between the back of the ischial tuberosities and the tip of the coccyx multiplied by this correction factor, is the true measurement of the posterior part of the antero-posterior diameter of the outlet.

CHAPTER XXXIV

CEPHALOMETRY

THOMS' METHOD OF CEPHALOMETRY

THE PRINCIPLES involved in radiological pelvimetry can be employed in favourable cases for an estimation of the size of the head of the full term foetus *in utero*. The patient is placed in the supine position on the Potter-Bucky diaphragm. The foetal skull is then orientated by abdominal palpation, the height of its occipito frontal diameter above the film is measured by means of callipers, and the inclination of the plane of this diameter to the horizontal is noted. A radiogram is then taken, with the tube centred at a measured height above the film, over the middle of the foetal skull. With the tube and film still in position the patient is removed and a lead plate with perforations 1 cm apart is introduced in the same plane as that previously occupied by the occipito frontal diameter, and a further exposure made on the same film. On the film the space between the perforations will be enlarged in the same proportion as the occipito frontal diameter. The measurement of the latter can therefore be directly obtained from the slightly magnified centimetre scale formed by the perforation dots on the film.

From an extrauterine study of 149 foetal heads which had not been subjected to moulding, *Thoms* constructed a table showing the relation of the occipito-frontal diameter to the biparietal diameter. This is given herewith.

Given an occipito frontal diameter of

12.5 cm subtract 2.5 cm for biparietal diameter						
12.0	,	"	2.5	"	"	"
11.5	"	"	2.0	"	"	"
11.0	"	"	1.75	"	"	"
10.5	"	"	1.5	"	"	"
10.0	"	"	1.5	"	"	"
9.0	"	"	1.5	,	"	"

Cephalometry is obviously most precise when the occipito-frontal diameter lies exactly transversely, i.e. parallel to the film in the supine position of the patient. In such cases, if we measure the height of the occipito frontal diameter above the film, and the height of the tube above the film, we can employ the perforated lead sheet method of *Thoms* or the geometric principle of *Roberts*, to deduce the exact measurement of the occipito frontal diameter.

Having obtained this, the biparietal diameter can be estimated by reference to *Thoms' table* as given above

If however, the head is tilted slightly, the diameter shown on the film will not be the true occipito frontal diameter, but will be an oblique diameter

ROWDEN'S METHOD

Rowden advocates the taking of the cephalometric radiogram with the patient sitting in the same position as for pelvimetry. The cephalometric and pelvimetric measurements by this means are available from the single radiogram. He employs standard cephalic scale strips for the cephalometric estimations prepared in the same manner as those for pelvimetry, the appropriate scale being chosen according to the height of the centre of the foetal skull above the film (6 to 9 inches with $\frac{1}{2}$ inch intervals)

WALTON'S METHOD

The patient is placed in the supine position with the foetal skull over the centre of the Potter Bucky diaphragm

(1) A mark 'A' is made on the anterior abdominal wall over the centre of the child's head

(2) A mark 'L' is made on the lateral abdominal wall on the side nearest to and directly opposite the centre of the child's head

(3) An antero posterior radiogram is taken centring the tube vertically above the mark 'A'. The vertical heights of the tube and of the mark 'L' above the film are measured

(4) A lateral radiogram is taken (with the film on the side next to the mark 'L') centring the tube horizontally opposite the mark 'L'. The horizontal distances of the tube and of the mark 'A' from the film are measured

By applying the geometric principle illustrated in Fig. 271 the true occipito frontal and biparietal diameters of the foetal skull can now be estimated

REECE'S METHOD

Reece concentrates on the measurement of the biparietal diameter. According to his conception the foetal skull (exclusive of the facial bones) is roughly egg shaped, the long axis of the ovoid being the occipito frontal diameter and its short axis representing either the biparietal or suboccipito vertical or an intermediate diameter of what he calls the greatest circular section. In any radiogram of the foetal skull some diameter of this greatest circular section is shown. From the nature of the cephalic shadow the biparietal diameter can be estimated from the radiogram. For this purpose we must know (a) the distance of the nearest point of the skull from the tube (TP), (b) the distance of the film from the tube (TF).

In order to arrive at the distance from the tube of the centre (II) of the

plane shown in the radiogram 2 inches is added to the measurement TP for all cases near term (Where instead of using the approximate estimate of 2 inches greater accuracy in the factor PH is desired this may be allowed for by a consideration of the age of the foetus and the shape of the cephalic shadow seen on the film Such a refinement however is as a rule not called for)

Employing the principle illustrated in Fig. 271 the correction factor is

$$\frac{TH}{TP} \text{ or } \frac{TP + 2}{TF}$$

In his technique the patient is placed in the supine position on the Potter Bucky couch the foetal skull is carefully palpated and the tube centred over the highest point palpated (P) A constant tube film distance (in this case 30 inches) is maintained

The distance (TP) of the target of the tube from this point is measured by means of a telescopic measuring rod attached to the tube (allowance is made for the thickness of the abdominal wall) The measurement TP is recorded and the exposure made

After development the short axis (a diameter of the greatest circular section) is measured on the film

By reference to tables the biparietal diameter can be readily obtained

McDONOGH'S METHOD

In *McDonogh's* method as in *Reece's* method the biparietal measurement alone is considered as from the obstetrical aspect it is of major importance the diameter of the greatest circular section which is seen in all projections irrespective of its relation to the film is here regarded as equivalent to the biparietal measurement

The technique is as follows The patient is placed on the Potter Bucky diaphragm (flat type) in the prone position if possible or failing this supine The approximate centre of the foetal head is located by palpation and adjusted over the middle of the Potter Bucky diaphragm immobilisation being secured by the usual band in a position which will not interfere with placing a film in line with the head

A film is then placed alongside the patient on the side nearer to the foetal head A graduated lead rule resting vertically on the Bucky surface is interposed between the patient and film A Lvhholm grid is of assistance but is not essential

The X-ray tube is positioned on the opposite side of the patient so that its central ray is projected horizontally through the mid point of the foetal skull the exposure made and the film removed

A second film is placed in the Bucky diaphragm and the tube brought to the standard height vertically above the centre and a second exposure made The time interval between the two exposures should be as short as possible to avoid foetal movement

The height of the foetal head above the second film will be indicated by the image of the lead rule on the first. Selecting from the complete set of standard scales, kept in the X-ray department, that corresponding to the height indicated the biparietal diameter is measured direct from the image on the second negative.

For routine work a set of standard scales is necessary, but if the number of cases is small the measurement may be obtained by using the following equation:

$$CD \times \frac{tf - sf}{tf} = d$$

When CD = Greatest circular diameter of head as measured on the negative

tf = Distance from X-ray tube to film

sf = Height of foetal skull above film

d = Actual greatest circular diameter of foetal skull
= biparietal diameter

PREPARED STANDARDS—Before making a set of standard scales one must decide upon the height at which the X-ray tube is to be operated and this setting must be adhered to in all subsequent measurements with the particular scales.

If the power available will allow a distance of 4 feet or more should be chosen but with a low powered plant 25 inches may be used successfully, though the accuracy diminishes as the distance is decreased.

A rule made from sheet lead about 1 inch wide and reinforced by wood or metal strips is required. One edge is marked by fine saw cuts at intervals of $\frac{1}{2}$ inch and the other at intervals of 1 cm.

This rule is set above the centre of the Potter-Bucky diaphragm (flat type) at a height of 3 inches and with the tube at the predetermined height, radiographed on to a section of 15 x 12 inch film, the remainder of which is protected by sheet lead. The rule is then raised to 3½ inches and radiographed on to a fresh section of film. This process is continued up to a height of 10 inches. Each section at the time of exposure is marked by means of lead numbers to indicate the height of the rule.

The films on which the images of the lead rule have been unprinted are processed in the usual way and after washing each is squeezed between two sheets of clear celluloid and allowed to dry slowly before cutting into strips. The celluloid is used as a protection for the gelatine against moisture or abrasion. A smear of 'Durofix' along their edges renders the scales water proof and allows one to measure direct from wet films without damage.

DISPROPORTION

Valuable information can be obtained regarding the relative size of the foetal head and maternal pelvis by direct radiography in the prone spine,

and lateral views It is important to bear in mind that in supine views the foetal head is nearer the X-ray tube than is the pelvic brim, the former will therefore be enlarged out of proportion to the latter In prone positions the converse holds Comparison of the prone and supine radiograms, supplemented by a lateral radiogram, will usually give the desired information as to the relative size of the foetal head and maternal pelvis

More precise information will, of course, be obtained by combined radiological pelvimetry and cephalometry In comparing the pelvic measurements with the cephalometric ones, however, one must bear in mind that both the maternal bony pelvis and the foetal bony vault are clothed with soft tissues (Thoms, by checking his results before and after delivery by Cæsarean section, finds that 2 mm must be added to the cephalometric measurements as an allowance for the thickness of the scalp)

The reader should be reminded that the radiological demonstration either of a normally sized pelvic brim or of a normally sized fetal head does not necessarily ensure normal delivery A large head may give rise to just as much difficulty in passing through a normally sized pelvis as a normal head will cause in the case of a contracted pelvis

In other words, to assure as great a degree of safety as is possible, both a normal pelvic brim and a normal or small fetal skull must be demonstrated

One is driven to repeat that while both radiological pelvimetry and cephalometry have their uses the best pelvimeter, in vertex presentations is the foetal skull Where this cannot be applied then the radiologist can give very valuable information which may save the mother's life, by indicating to the obstetrician the necessity or otherwise for Cæsarean section before obstetrical interference per vaginam has been allowed to add to the risks of such a procedure

Furthermore one must bear in mind that normal delivery may conceivably take place even where there is an apparent disproportion for the radiologist is unable to assess two unknown factors, viz the strength of the uterine contractions, and the degree of skull moulding which will take place during labour

Radiological pelvimetry, if properly performed, is a procedure of precision, and the measurements do not normally alter to any appreciable degree as the result of parturition Cephalometry, on the other hand, lacks this degree of precision and the measurements alter considerably during the course of normal labour

CHAPTER XXXV

THE RADIOLOGICAL ESTIMATION OF FETAL MATURITY

Though in many cases the clinical history is sufficiently reliable to justify a reasonably accurate estimate of maturity of the fetus, an element of doubt not

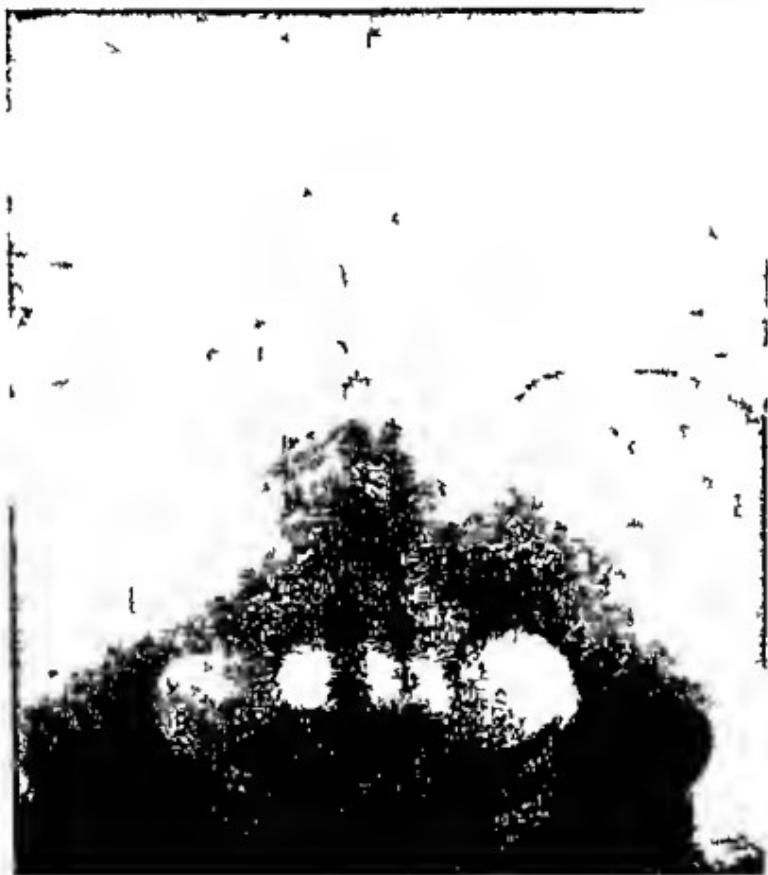


FIG. 76.—Patient in supine position. Simulation of hydrocephalus by normal skull due to anteroposterior position of head (case of twins). Compare Fig. 77 of same patient in prone position.

infrequently arises owing either to uncertainty about the date of the last menstrual period or to conception having occurred during a period of amenor-

rhea (as in lactation), or to a discrepancy occurring between the size of the gravid uterus and the clinical estimate of maturity.



FIG. 277.—Same patient as Fig. 276, patient in prone position; normal-sized skull (twins).

The radiologist, when asked to help in the assessment of the foetal maturity, usually bases his estimation on two factors :

- (i) The size of the fetus.
- (ii) The stage of ossification of the foetal bones.

Most radiologists of experience will have formed a fairly reliable mental impression of the size of the fetus at different periods of gestation. In doing so they will probably have observed two important rules, viz.:

- (i) The maintenance of a standard distance between the X-ray tube

the film a convenient distance being 30 inches (Comparisons of size cannot be satisfactorily made unless a standard distance is maintained)

(ii) The routine taking of a radiogram with the patient in the prone position This is necessary because by adopting this position, the foetus is brought closer to the film and its film image is thus enlarged or distorted as little as possible

The difference in size between the foetal skull on a radiogram taken in the prone position and that of the same patient taken in the supine position is at times most marked (Figs. 276-277)

In estimates of age from a mere inspection of films however, the personal element enters too largely into interpretation to allow of the method being of universal utility and a more precise method is obviously desirable

Such a method has for some time been in vogue in the practice of cephalometry the measurement by means of X rays of one or other of the diameters of the foetal skull Up till recent times the diameter usually measured has been the occipito frontal If this diameter lies parallel to the film it is a matter of ease to measure its exact length from the radiogram either by the grid method of *Thoms* or by the geometric principle of *Walton*

Obviously in this method the foetal head must be orientated with precision for any appreciable degree of obliquity of the occipito frontal diameter (except in the method of *Thoms*) will render the attempt to estimate this diameter difficult or even impracticable

According to *Scammon* and *Collins* the occipito frontal diameter bears a definite relation to the age of the fetus The following table has been abstracted from their chart

Age of Fetus in Calendar Months	Occipito-frontal Diameter
End of third month	2.8 cm
fourth	4.8
fifth	5.6
sixth	6.2
seventh	7.7
eighth	10.0
ninth	12.2

By examination of a large number of foetal skulls at different stages of maturity however *Scammon* and *Collins* find that considerable individual variations may occur (Fig. 278) It is obvious that whilst a certain length of the occipito frontal diameter may *on the average* correspond to a certain period of gestation an estimate of maturity based on such measurements may in any individual case be as much as three or four weeks out of reckoning

REECE'S METHOD OF ESTIMATING MATURITY

The biparietal diameter of the foetal skull is estimated by the method described on page 402

On the assumption that the biparietal diameter increases by $\frac{1}{10}$ inch per week during the last few weeks of pregnancy to attain a measurement of 3.75 inches at full term, *Reece* estimates the number of weeks from full term which the foetus has reached, he claims a considerable degree of accuracy in his results.

ROBERTS' METHOD OF ESTIMATION OF MATURITY

If the presentation be a vertex the patient is placed in the prone position with a 12×10 inch cassette beneath the hypogastrum, the Potter Bucky diaphragm not being used. She is postured so that the hypogastrum is as nearly as possible in contact with the cassette.

The tube is centred 4 feet vertically above the cassette and a radiogram is taken. Though not of the same quality as a Potter Bucky radiogram the foetal skull is shown with sufficient clarity to allow of its suboccipito bregmatic diameter being measured on the film. Provided the skull is normal in size and the hypogastrum is touching the cassette the sub

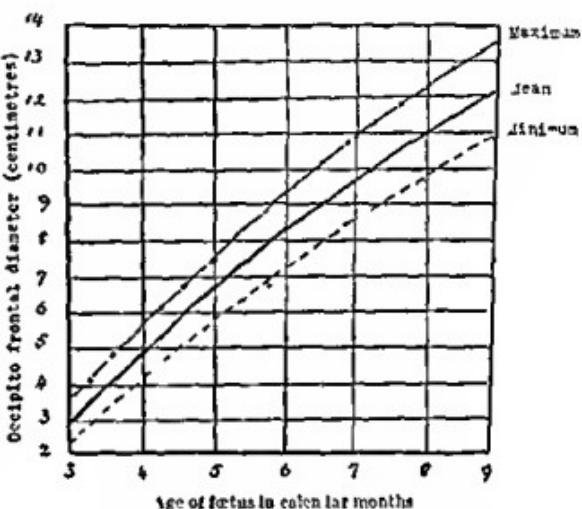


FIG. 278.—Variation of occipito frontal diameter with age of fetus. (From Scanlon and Calkins.)

occipito bregmatic diameter in inches multiplied by ten gives approximately the number of weeks of maturity. This applies only to a patient of average build whose hypogastrum has been brought into actual contact with the cassette. If the patient be fat or if her hypogastrum cannot be brought into contact with the cassette or if a lateral view shows the position of the head to be occipito posterior, a week, or in extreme cases two weeks, should be deducted from the maturity computed as above.

(The method is based on the principle that under the conditions described a true suboccipito bregmatic diameter of 3.75 inches becomes a film diameter of 4 inches due allowance being made for the estimated distance from the film, in an average case, of this diameter.)

It should be emphasised that *Roberts'* method of estimating maturity here described is only applicable (a) during the last two months of pregnancy, and (b) in vertex presentations, where, in the prone position of the patient, the

foetal skull is close to the cassette. In breech presentations an element of uncertainty is introduced by the variable height of the foetal head. The chief merit of this direct or non Bucky method lies in its simplicity.

Limitations of Cephalometric Methods of Estimating Maturity—Cephalometric methods of estimation of maturity would be of greater reliability if all foetuses when delivered were of a standard size, but as a full term foetus may vary in weight from 4 lb to 9 lb, it is unreasonable to expect all of them to have biparietal diameters of a standard size.

Whilst on the average the radiological estimates of maturity are found to be fairly accurate individual cases occur in which the discrepancy on either side may be as much as three weeks. Because of this variation from the average which may occur in any individual case no cephalometric method of estimating maturity can be regarded as universally reliable. In any case of clinical doubt as to maturity such methods are however justifiable as being the only alternative means at our disposal. But it must be realised that they are not infallible in their results.

ESTIMATION OF MATURITY FROM OSSIFIC CENTRES

Apart from the general size and cephalometric measurements there is another point needing brief consideration namely the stage of ossification of the bones. The radiologist develops a general idea of their X-ray appearances and degree of calcification from thirteen weeks (when they are first demonstrable) to full term and beyond that to post maturity. There are however certain ossific centres which make their appearance during the later months of pregnancy which have been regarded as of special importance. These are the ossific centres for the lower epiphysis of femur the upper epiphysis of the tibia the os calcis astragalus and cuboid.

The average dates of appearance of these centres are as follows:

Osculum	9th week
Astragalus	4th to 32nd week
Cubo	40th week
Lower epiphysis of femur	35th to 40th week
Upper epiphysis of tibia	40th week

Unfortunately however these are merely averages and in any individual case considerable variations may occur. For instance one has occasionally encountered a foetus of thirty-seven weeks in whom both the femoral and tibial epiphyseal centres were very well developed and clearly visible on the radiogram or a foetus of forty weeks in whom neither was present being completely absent on good radiograms showing clearly the foetal knee joint.

POST-MATURITY

In cases where the patient is suspected of having gone beyond the computed date of delivery the radiologist may be called upon to decide whether the

fœtus is post-mature or not. In post maturity he will find a large but well-ossified cranial vault, well defined but not large fontanelles, massive and well-ossified limb bones, frequently large and well developed ossific centres for the lower end of the femur and upper end of the tibia, and well developed ossific centres for the os calcis, astragalus, and cuboid.

The differential diagnosis between the large and well-ossified head of the post-mature fœtus and the large head of the hydrocephalic fœtus with comparatively thin cranial bones and wide fontanelles is referred to later.

MEDICO-LEGAL ASPECTS

In cases of suspected criminal abortion the radiologist may be called upon to examine the charred remains of the fœtus in order to decide whether the fœtus was viable or not at the time of its destruction. It is therefore important to know what ossific centres are normally present in a fœtus of twenty-eight weeks' gestation, and more particularly those which appear after this.

The ossific centres which appear between the twenty-eighth and fortieth week are the following (*Holmes and Ruggles*)

Hyoid bone greater cornu	29th to 32nd week
Coccyx	37th to 40th week
Lower epiphysis of femur	39th to 40th week
Upper epiphysis of tibia	40th week
Astragalus	24th to 32nd week
Cuboid	40th week
Middle phalanx fourth toe	29th to 32nd week
Middle phalanx fifth toe	33rd to 36th week

Radiographic demonstration of air in the lungs or stomach of a dead child is of value in deciding whether or not the child lived after birth (*Hajlis*).

CHAPTER XXXVI

THE FETUS POSITION PRESENTATION AND ABNORMALITIES POSITION AND PRESENTATION

WITH RADIOGRAMS in two planes (supine or prone and lateral) the position of the fetus is readily demonstrated and we can say whether the occiput or sacrum is to the left or to the right and anterior or posterior.



FIG. 270.—Brow presentation—extension of head 1 at no normal form (cf. Fig. 279.)



FIG. 280.—Breech with legs flexed

Similarly the presentation—vertex, brow, shoulder, transverse, breech, etc—is clearly shown

Furthermore, valuable information is available as to the degree of flexion or extension of the head (Fig. 279) the position of the lower limbs (whether flexed or extended in breech cases (Figs. 280, 281, 282) a matter of great importance in influencing the success of version) and the position of the hands in relation to the foetal head



FIG. 81. Breech with Legs extended.

With a motile fetus however it is sometimes disconcerting to note the sudden changes in position which may occur even at the seventh month or so. On one occasion in the author's experience complete version of a breech presentation was spontaneously performed during the brief interval which elapsed during the turning over of the patient from the supine to the prone position. At any stage prior to the middle of the ninth month the radiologist should therefore be careful to state in his report that 'at the time of the examination' the position and presentation were 'so and so.'



FIG. 282.—Full-term fetus Breech with extended legs Well developed femoral and tibial epiphyseal ossific centres

MULTIPLE PREGNANCY

One cannot help being impressed by the frequency with which, in cases of hydramnios, twins are demonstrated radiologically where no opinion as to their presence has been formed clinically, and alternatively the frequency with which a multiple pregnancy has been proved radiologically to be absent when a



FIG. 283.—Twin— forecoming, vertex aftercoming breech

tentative diagnosis of such has been made clinically. In this respect the radiographic evidence is usually beyond question (Figs. 283, 284). It should be emphasised, however, that the exclusion of the possibility of multiple pregnancy should be made only after at least two satisfactory radiograms have been taken. Every radiologist of experience will be able to recall cases in one radiogram, but, because of a burst of



Fig. 24-T ns Both recoil

fetal motility on another radiogram of the same patient no signs of the fetus were visible. This might quite feasibly happen to one of a pair of twins.

Triplets are occasionally seen (Fig. 28a).

When reporting the radiologist should give details as to the position and presentation of each fetus shown with special reference to the forecoming fetus.



FIG. 8.—TYPICAL (INT. REL. W. OF UL. RU.)

EXTRAUTERINE PREGNANCY

If in the radiogram part or whole of the fetus can be seen to lie outside the uterine shadow the radiological diagnosis of extruterine pregnancy can be made with certainty.

Extrauterine pregnancy may sometimes be suspected from an unusually high or abnormal position of the fetus. In such cases however a most careful collaboration between the radiologist and the obstetrician is of paramount importance. Pneumoperitoneal radiography will give valuable information. Radiography after the introduction of a rubber tube into the uterine cavity (if considered justifiable) may lead to error in the presence of a bicornuate uterus. Radiography after the introduction of hpiodol into the uterine cavity may reveal a normally shaped or elongated uterus in ectopic pregnancy. This method however is not justifiable except in confirmation of the strongest clinical or radiographic suspicion of extrauterine pregnancy and where a termination of the pregnancy in any event is desirable.

FETAL ANOMALIES AND ABNORMALITIES

On many occasions when hydramnios has been present and when the obstetrician has been in doubt as to its cause the revelation of a gross fetal abnormality by radiography has made the diagnosis clear.

In the antenatal demonstration of fetal abnormalities radiology plays a part of the greatest importance for precise knowledge of their presence and presentations may by forewarning the obstetrician not only save him from considerable embarrassment at delivery but may empower him to concentrate boldly on measures which aim at the saving of the mother's life regardless of that of the fetus.

The common abnormalities of this type which may be shown by X rays are the following:

Hydrocephalus — The frankly hydrocephalic skull is readily demonstrated radiologically (Fig. 286). The large size of the fetal skull in relation to its body and to the size of the maternal pelvis usually establishes the diagnosis beyond doubt. At full term it is sometimes difficult to differentiate between a mild degree of hydrocephalus and the large skull of post maturity (Fig. 287). In the latter however the thick and well calcified cranial bones, the normally sized fontanelles and the size and advanced degree of ossification of the limb bones combined with the clinical history will usually settle the diagnosis. Occasionally it is very difficult to decide precisely from the radiograms whether a mild degree of hydrocephalus is present or not.

The recent work of *Holash* who after definitely establishing a diagnosis of a hydrocephalic vertex presentation by radiography has perforated the enlarged fetal skull per abdomen so that the head thus reduced in size might pass

through the maternal passages without difficulty, is of interest (Figs. 288-289).

Anencephaly.—Whilst a diagnosis of anencephaly may often be made on clinical evidence alone cases are occasionally encountered in which the



FIG. 288.—*H. Inceptus.* Note the cranial defect and wide fontanels.

abnormality (associated with hydramnios) has been clinically mistaken for a breech presentation with no suspicion as to anencephaly.

The radiographic appearances showing the absence of the rounded cranial vault are characteristic (Fig. 289). Occasionally an additional abnormality such as spina bifida is seen on the radiogram (Fig. 291).



FIG. 297.—Post-mature foetus. Note thick cranial bones and well developed limb bones. Femoral centres clearly visible.

In demonstrating this condition radiograms should be taken in such position as will throw the shadow of the foetal skull clear of the maternal skeleton. The lateral view is often of value in such cases.

Intencephaly—This is a condition associated with an imperfect formation of the occiput in the region of the foramen magnum *spina bifida* (often of considerable extent) and retroflexion of the cervical spine (*Ballantyne*)



FIG. 258.—Hydrocephalus before tapping by puncture of skull.



Fig. 289.—Hydrocephalus after tapping by puncture of skull. Easy delivery ensued.



FIG. 200. Last mature ac. neep ba. fat. - Note large f. moral and b. allow flower tree.



FIG. 291.—Lateral view of uterus, meningocele, and spina bifida



Fig. 92.—In cephalic presentation with well marked angular spinal deformity due to spina bifida.

Sometimes the skin and tissues clothing the skull press directly from the back of the vertex on to the back of the thorax of the foetus without any intervening suboccipital depression.

Care must be taken in reading the radiogram not to mistake for men cephalis a simple hyperextension of the head and it must also be

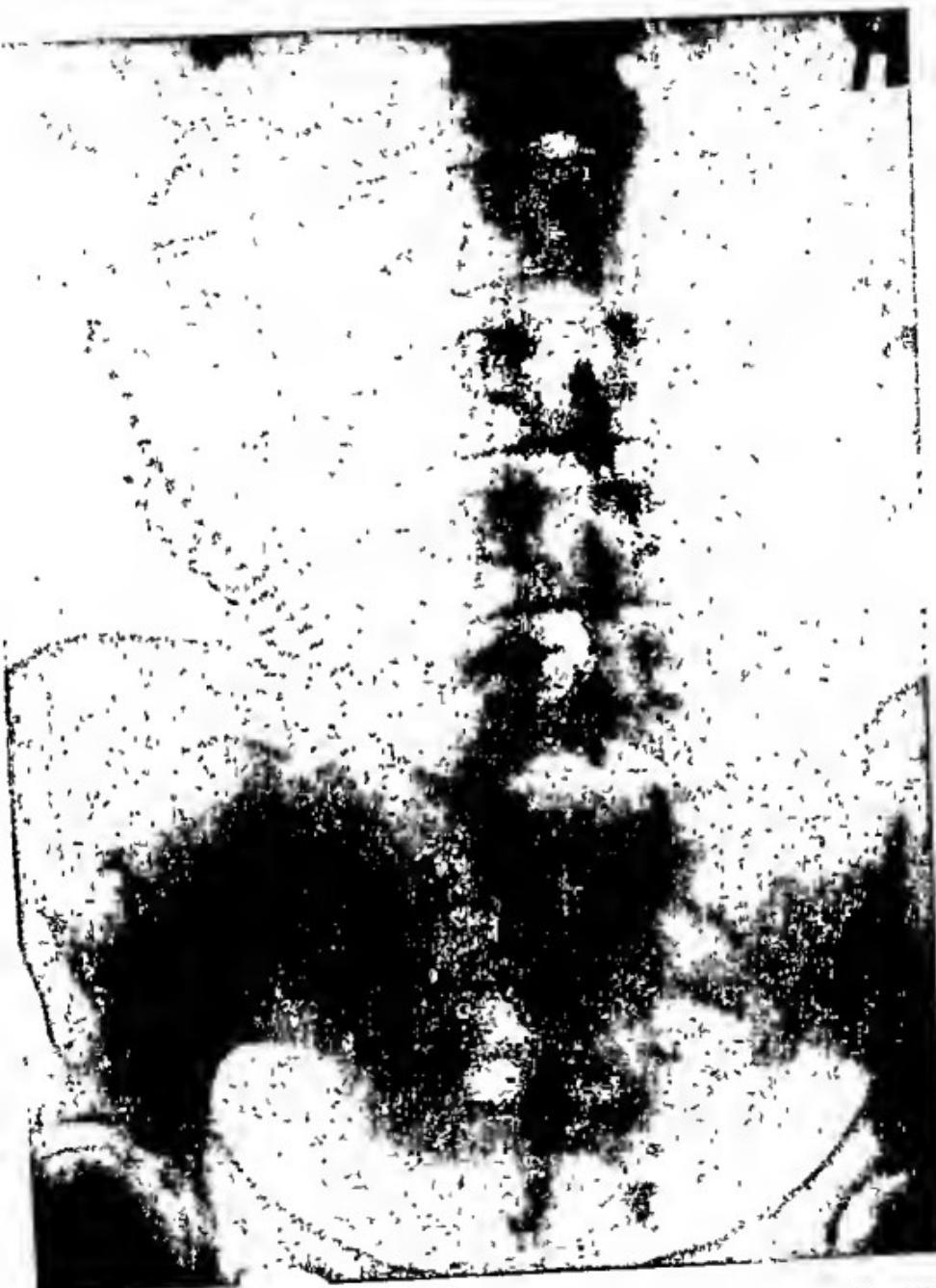


FIG. 293.—Foetal thyroid tumour. Note hyperextended head but no spinal deformity (cf. Fig. 292).



FIG. 291. An except from a film made of a fetus (3 months) showing a large dorsal mass.

remembered that hyperextension of the cervical spine may be caused by thyroid tumours.

In microcephaly the diagnostic radiological feature is the demonstration in a foetus whose head is hyperextended of an abnormality of the cervical spine or occiput. Fig. 292 shows such a condition in which this combination is clearly shown.

Thyroid Tumour. Where this is present in the foetus (Fig. 293) the head is hyperextended but there is no abnormality of the cervical spine as seen in

encephaly. The antenatal diagnosis of such a lesion cannot be made by direct radiography alone. Amniography in a suspected case may be helpful.

Spina Bifida—In any radiogram where the normal spinal curve of the fetus



FIG. 9a.—Meningocele. High position of fetus. Abnormality of occipital bone noted.

is seen to be altered the possibility of spina bifida should be considered. In such cases radiograms should be taken in different positions so as to bring the fetal spine into profile i.e. to produce a direct lateral view of the foetal spine.

In spina bifida there is seen to be an alteration in the normal spinal curves,

together with a defect in the formation of the spinous processes in the affected area (Fig. 294).

Meningocele.—Though the sac of a meningocele cannot be differentiated from the liquor amni by direct radiograms, the possibility of such a lesion should be borne in mind in any case where a defect or an abnormal shape of the skull bones is shown, or where there is a suspicion of spine bifida. Fig. 295



FIG. 295.—Meningocele. *Fetus after delivery*. (Same case as Fig. 215.)

shows a case in which an abnormality of the occipital bone was observed in the antenatal radiogram together with a high position of the fetus, while a soft sac could be palpated per vaginam. The patient went into normal labour the same day. Fig. 296 shows the fetus after delivery.

Rudimentary Limbs.—A satisfactory series of radiograms should show all the fetal limbs in detail. Any abnormality should be reported.

Fig. 297 shows a case in which rudimentary fetal arms were diagnosed before birth. Fig. 298 shows this fetus after delivery. The additional diagnosis of intrauterine death in this case was also made antepartum. This was made possible only after two radiographic examinations at a week's interval had been made and the fetus was seen to have failed to increase in size in the interval. Spalding's sign (see later) was only doubtfully positive.



FIG. 294.—Intrauterine death and voluntary upper limb (fetus dead before delivery)

INTRAUTERINE DEATH

The most reliable sign of intrauterine foetal death is that described by Spalding viz an overriding of the cranial bones. This is due to shrinking of the brain with consequent falling in of the vault and may be found within four to seven days of intrauterine death (Matthews) (Figs. 299-300-301).

Care must be taken not to confuse the overriding or moulding of foetal death with that which normally takes place during engagement of the head or more markedly during labour (Fig. 302). Very rarely overriding may be seen

where there is neither intrauterine death nor where the patient is in labour, possibly such cases may be associated with scanty liquor amni.

Spalding's sign of overriding seen at a single radiographic examination can



Fig. 218 Fetus of Fig. 217 after delivery. Note rudimentary upper limbs. Ossific centres for os calcis and astragalus well developed.

therefore only be regarded as strong *presumptive* evidence of intrauterine death and must be carefully correlated with the clinical evidence.

Other radiographic signs of intrauterine death have been described these are

(1) Lordosis of the lumbosacral fetal spine (*Jungman*). This sign is of little value and often cannot be seen unless the fetal spine is shown exactly in



FIG. 299.—Intrauterine death—overlapping of cranial bones (Spalding's sign).

profile—an obliquity of position of the foetus may mask it—and it may be present in the case of living twins.

(2) Falling in of the thorax (of very doubtful significance) or marked kyphosis of the dorsolumbar spine.

(3) Osteoporosis of the foetal bones. This is more likely to be due to a faulty metabolism of the mother or it may be simulated by the use of too penetrating a ray.

(4) A foetus which is much too small for the period of amenorrhoea. The foetal maturity can be estimated by the method described earlier. If this be found to fall short of the clinical estimate by a month or more a suspicion of



F. 300 Breech 1 hr. ante partum (Spald. 22 x 21 mm.)

fetal death is raised but it must of course be remembered that the menstrual history is not always reliable.

It must be emphasised that an absence of overlapping of the cranial bones does not necessarily imply a living fetus. In 50 per cent of the cases of intrauterine death radiographed by the author no overlapping was visible at the first radiographic examination. In any cases of clinical or radiological

doubt, therefore radiograms should be taken periodically (say at weekly intervals) till it can be definitely decided that Spalding's sign is positive or that the foetus is neither growing nor moving. A lowering of the level of the



FIG. 301 Intra-uterine death (Spalding's sign positive)

fundus of the uterus or an increase in the spinal curve of the fetus shown after an interval is also strong presumptive evidence of fetal death.

It will of course be appreciated that X-ray evidence in such cases will necessarily be complementary to the clinical evidence—a close collaboration between the radiologist and the obstetrician is imperative if mistakes are to be avoided.

CHAPTER XXXVII

PLACENTA PRÆVIA

In a case of antepartum haemorrhage it is of the greatest importance to the clinician that he should be able to ascertain whether this bleeding is of the nature of an 'accidental haemorrhage' due to a detachment of a normally placed placenta or whether it is due to the more serious complication of *placenta prævia*.

If the cervix be sufficiently dilated, either through labour having started or through the haemorrhage having been profuse, the clinician may be able by means of the palpitating finger to decide whether the placenta is encroaching on the os uteri. If the cervix is closed, however, this is not possible and the help of the radiologist may be invited in an effort to decide whether the placenta is normally placed or whether it is partially or wholly implanted on the lower uterine segment.

DIRECT RADIOGRAPHY

Snow and Powell claim that by a careful inspection of good films of the gravid uterus they can pick out the placenta as a half shadow between the boundary of the uterus and the foetal parts but they include no cases of *placenta prævia* in their series.

Attempts have also been made by *Staudley* to diagnose the position of the placenta from an examination of radiograms of the gravid uterus, in which there were sometimes shown groups of shadows which were thought might be due to phleboliths or calcified patches in the placenta. By a radiographic examination of a number of such cases before and after parturition, together with the placenta after extrusion I have convinced myself that such calcifications are as a rule not in the placenta, but in mesenteric glands which have been displaced by the gravid uterus. To base an opinion as to the placental site from the presence of such calcified patches is therefore liable to lead to error as there is no means by which one can be certain whether such calcifications are in the placenta or in the glands.

AMNIOGRAPHY

(Radiography after injection of opaque fluid into the amniotic sac)

Menees, Miller and Holly by the injection of strontium iodide into the amniotic sac in pregnant women found that this substance, mixing with the

liquor amnii and being opaque to X rays gave a satisfactory amniogram i.e. a radiographic shadow representing the amniotic cavity. The foetal parts and the placenta were seen as more translucent areas in the more opaque liquor amnii.



FIG. 30.—Molding of k. B. Erne labour (not to be confused with Spall sign of intrauterine death.)

The placenta is disposed edge-on to the incident X-ray beam therefore showed as a filling defect on the edge of the amniotic sac and its site could thus be ascertained. They recorded no ill-effects either to mother or child.

Munro Kerr and Mackay in adopting this method found that in some of their cases the injection of strontium iodide into the amniotic sac resulted in the death of the fetus. They therefore substituted Uro electan B for strontium iodide. In a series of ten cases they obtained good results with no fetal

fatalities. They found however that even this non toxic and non irritant medium tended to terminate pregnancy.

Technique—The injection is made at a site chosen in the lower half of the abdomen where it is least likely to damage the foetus, i.e. over the site of the fetal limbs the maternal skin having been previously sterilised and anaesthetised.

When the point of the needle is felt to have entered the amniotic cavity, 20–50 c.c. of amniotic fluid is withdrawn (this is not always essential) and 20–50 c.c. of Uroselectan B is then injected slowly, an occasional slight withdrawal of fluid being made at intervals during the injection to make sure that the point of the needle is still free in the amniotic cavity. The method should not be employed if there is present a scar of an abdominal incision as there may then be a risk of puncturing adherent gut.

During the next half hour mixing of the drug with the amniotic fluid is encouraged by placing the patient in different positions every few minutes. A series of radiograms is then taken (on 17 × 14 inch films) in different planes—antero posterior, lateral and oblique—so that in one or other of them the placenta is end-on and a corresponding filling-defect can be made out on the radiograms. The differential diagnosis between accidental haemorrhage and *placenta previa* is thus made possible by the visualisation of the placental filling defect in the upper or the lower part of the uterus (Figs. 303, 304).

The diagnosis is sometimes rendered difficult by the appearance of pseudo filling defects on the boundary of the uterine shadow due either to the presence of translucent gas filled bowel or of surrounding structures or to the presence of a large blood clot between the wall of the uterus and the bag of membranes. Other less likely sources of error might be the presence of a fibroid or the existence of multiple pregnancy.

Kerr and Mackay found that as a result of the injection of Uroselectan B, labour was brought on after an interval varying from a few hours to five days. For this reason the method should be restricted to the later weeks of pregnancy. In course of time no doubt some substance will be discovered which is still less irritant than Uroselectan B and which will not cause an induction of labour.

Burke reports a series of seventeen cases in whom he performed amniograms with Uro-selectan B. In twelve cases in which large (17 × 14 inch) films were used the position of the placenta was accurately diagnosed by this method. In four cases the examination was spoilt by the use of smaller (15 × 12 inch) films. He therefore stresses the desirability of using the larger sized film.

He points out that the diagnosis of the site of the placenta is difficult only if the placenta is implanted in the upper part of the uterus where the shape of the uterine fundus is inconstant and where intestinal gas may produce



F 303.—Amnogram showing.—Lateral placenta praevia in case of antepartum haemorrhage (fibrin deposits on wall of uterus marked by dotted line). Confirmed by intrauterine palpation after delivery of fetus. (Note shadow of Uroselectan in amnion of cat liver and also stomach and intestines of fetus.)



FIG. 301. Amniogram showing lateral placenta previa in a case of antepartum haemorrhage (oblique view). Placental filling defect seen to be intermediate density between the Uroselectan in the amniotic cavity and the extramembranous transluencies. (Note Uroselectan in fetal stomach and intestines.)

pseudo filling defects. In his series the radiological diagnosis was accurate in all cases of placenta prævia investigated.

In the later weeks of pregnancy he regards the inevitable induction of labour which results from the injection of Uroselectan B as being relatively unimportant—he even goes so far as to advise the use of this injection method



FIG. 305.—Low placenta prævia. Note wide gap between fetal skull and fundus of bladder.

in suitable cases with the dehberite aim of inducing labour as being safer than the usual methods.

In thirty five cases where Uroselectan B was injected there was one instance in which death of the foetus occurred which could not be explained by natural causes.

If the amount of liquor amni is excessive the drug may be so diluted that the shadows obtained are too faint for precise diagnosis if the liquor is scanty uterine puncture may be unsuccessful.

Burke summarises the indications for amniography by stating that if in a doubtful case of placenta previa the history of the case, the physical signs and other important considerations—e.g. age of the patient, parity, desire for a live child, etc.—are sufficient to indicate that Cæsarean section is considered as a possible mode of delivery, then amniography should be performed. But if it is decided that delivery shall be *per utas naturales* in any case, then there is little



FIG. 306.—A case of antepartum hemorrhage. Increased gap between fetal skull and fundus of bladder due to a central clot (See Fig. 307.)

or nothing to be gained by subjecting the patient to the examination. The main value of amniography appears to be as a deciding factor for or against delivery by Cæsarean section. If the diagnosis proves to be one of central placenta previa, then Cæsarean section can be undertaken, with beneficial results to the child and in full confidence that the mother is not being exposed to unnecessary risk. If lateral placenta previa is diagnosed, natural delivery can be awaited without undue apprehension for the safety of the mother or the child.

CYSTOGRAPHY

Ude Weum and *Urner* made a preliminary report of a method by which they successfully diagnosed the presence of placenta prævia. The method consists of an injection into the bladder *per urethram* of a 12½ per cent solution of sodium iodide (which is radio-opaque). Normally in the later weeks of pregnancy the interior portion of the thin walled lower uterine segment lies



FIG. 307.—Same case as FIG. 306 two weeks later. The central clot has been absorbed or passed and the fetal skull and fundus of bladder now show a normal relation (p.

in close apposition to the postero superior margin of the bladder separated from it only by the reflection of the peritoneum. If therefore the foetal head lies in the lower uterine segment the gap separating it from the fundus of the bladder in a supine radiogram should be narrow whilst if there be a placenta prævia interposed between them the gap should be widened according to the degree of interposition (Fig. 306). The method therefore presupposes a vertex presentation and is not applicable to a breech or a transverse lie. Moreover the gap will be greater in the case of a central placenta prævia than in a partial placenta prævia depending on the differing thickness of placenta intervening.

A drawback of the method lies in the fact that a central blood clot will give the same cystographic appearances as a central placenta previa (Figs. 306-307). Furthermore the method is only applicable to vertex presentations in the latter weeks of pregnancy in the earlier stages of pregnancy there may normally be a wide gap between the fetal head and the fundus of the bladder.

The method is of maximum utility in the case of central placenta previa (provided the presence of a central clot can be excluded). In cases of lateral or marginal placenta previa the accuracy of the radiological diagnosis by this method is often in doubt.

Instead of injecting a radio opaque solution of sodium iodide into the bladder *per urethram* the oral administration of sodium ortho iodo hippurate (Iodoral Martindale) will give good cystographic results but we have no experience of this method. Similarly of course Uroselectan B injected intravenously can be used but the injection *per urethram* of sodium iodide commends itself because of its simplicity and because of the more certain control of the amount in the bladder.

DANGER TO MOTHER OR FÖTUS FROM OBSTETRICAL RADIOGRAPHY

Misconception on this point has arisen from a lack of appreciation by obstetricians and others of the difference between the dosage administered in deep X-ray therapy for pelvic carcinoma, menorrhagia etc (where intensive or prolonged doses of penetrating X-rays are given with destructive aims) and the comparatively small dosage received in diagnostic X-ray examinations.

The intensive dosage used in deep X-ray therapy of the pelvic organs has on occasion been responsible for the causation of fetal developmental abnormalities (Findley, Bailey and Hogg, Murphy). It can however be definitely stated that there is no evidence that diagnostic antenatal exposure is in any way harmful to the fetus or the mother. It is of course advisable to avoid any unnecessary repetition of radiographic examinations four or five diagnostic exposures however may be made at one session and repeated at intervals of one month if necessary without any risk of damage either to mother or fetus.

Goldstein and Murphy after an exhaustive review of the literature on the subject conclude that there is no evidence that diagnostic pelvic radiation during pregnancy is deleterious in any way to the health of the subsequent offspring.

Therapeutic X-rays should not be given to the pelvis if pregnancy is known to have occurred and if pregnancy occurs during the course of such treatment, the pregnancy should at once be terminated.

BIBLIOGRAPHY

- ALBANO, G., *Zentralb Gynäk.*, 1928, LII (2) 2084
 ALBERT, *Berlin Klin Wechschr.*, 1899, XXXVI, 537
 BAILEY, H., and BAGG, H. J., *Amer J Obstet.*, 1923, V, 461
 BALLANTYNE, J. W., "Antenatal Pathology and Hygiene The Embryo" Edinburgh, 1904
 BUPKE, F. J., *J Obstet Gyn (Brit Emp.)*, 1925, XLII, 1096
 CHASSARD and LAPINE, *J Radiol et d'Electrol.*, 1923, VII, 113
 COURTEEN GAGE, H., in "Recent Advances in Obstetrics and Gynaecology" (Bourne & Williams) London, 1932
 FINDLAY, P., *J A M A*, 1930, XCV, 857
 GOLDSTEIN, L., and MURPHY, D. P., *Amer J Roent.*, 1929, XXII, 322
 HAJKIS, M., *Lancet*, 1934, II, 134
 HEUSER, C., *Lancet*, 1925, II, 1111
 HOLMES, G. W., and RUGGLES, H. E., 'Roentgen Interpretation' London, 1926
 HOOTON, W. H., *Brit J Radiol*, 1932 V, 617
 JARCHO, J., "Gynaecological Roentgenology. *Innals of Roent.*, XIII, 388
 JUNGMAX, M., *Zentralb Gynak.*, 1928, LII, 2788
 KERP, J. M. M., and MACKAY, W. G., *Trans Edin Obst Soc.*, 1933, LIII 21
 McDONOGH, C. L., *Brit J Radiol*, 1935 VIII, 613
 MATTHEWS, H. B., *Amer J Obstet.*, 1930, XX, 612
 MENEES, T. O., MILLER, J. D., and HOLLY, L. E., *Amer J Roent.*, 1930, XXIV, 363
 MURPHY, D. P., *Amer J Obstet.*, 1930, XX, 724
 PETERSON, R., *Surg Gyn Obstet.*, 1921, XXX, 154
 REED, L. N., *Proc Roy Soc Med.*, 1933 XXVIII, 489
 ROBERTS, R. E., *Brit J Radiol*, 1927, XXII, II, *Ibid.*, 1935, VIII 601, *Proc Roy Soc Med.*, 1934, XXVII, 1211
 ROWDEN, L. A., *Brit J Radiol*, 1931, IV, 432, *Ibid.*, 1935, VIII, 610
 SCAMMOS, R. E., and CALKINS, L. A., "Development and growth of the human body in the fetal period" Univ Minnesota Press, 1929
 SNOW, W., and POWELL, C. B., *Amer J Roent.*, 1934, XXXI, 37
 SPALDING, A. B., *Surg Gyn Obstet.*, 1922, XXXIV, 734
 THOMS, H., *Amer J Obstet.*, 1922 IV, 257, *J A M A*, 1930, XCV, 21
 UDE, W. H., WEUM, T. W., and UPNER, J. A., *Amer J Roent.*, 1934, XXXI, 230
 WALSH, C. H., *Brit Med J.*, 1933, I, 1935
 WALTON, H. J., *Surg Gyn Obstet.*, 1931, LIII, 536, *Amer J Roent.*, 1931, XXV, 758

INDEX

A

- Abdominal wall, peritoneal gas inflation through, diagnostic applications, 369 technique of, 367
Abscess, appendix, localised, 221 liver, calcified, diagnosis from gall stones, 327 radiological appearances of, 349 perirenal, eversion of diaphragm in, 194 subhepatic, eversion of diaphragm in, 194 subphrenic, eversion of diaphragm in, 193 radiological appearances of, 193
Achalasia of cardia, 28 of pylorus, effect on gastric evacuation, 56 with gastric ulcer, 69, 70 Achylia gastrica, simple, gastric mucosa in, 81 Actinomycosis of colon, 266 of stomach 84 Addison's anaemia, atrophic gastritis of, 81 disease, radiological demonstration of, 353 Adhesions, gastric, 77 perigastric, contraction of, causing cascade stomach, 48 Adreno genital syndrome, peritoneal inflation in demonstration of, 355 Aerophagy, pathological, 112 Air insufflation of stomach, 43 Akerlund deformity and retraction in duodenal ulcer, 131 Alimentary canal, examination of, barium emulsion for, 34 general technique, 34 foreign bodies in, opaque, 106 transparent, 107 Amniography, 436 dangers of, 438 indications for, 440 technique of, 438 Amniotic sac, injection of opaque fluid into, 436 Ampulla of Vater, dilatation of, 142 normal, radiological appearance of, 123 Anaemia, Addison's, atrophic gastritis of, 81 Anencephaly of fetus, radiological demonstration of, 420 Antiperistalsis of colon, 239 Antonucci's technique of cholecystography, 317 Aperients preceding barium meal examination, 37 Appendicitis, chronic, pathology of, 216 radiological signs of, adhesions, 218 appendicular stasis, 220 concretions, 217 fixation of appendix, 218 fixation of cecum and ileum, 218 gastric stasis, 221 ileal stasis, 220 irregularity of lumen, 217 non or incomplete filling, 217 tenderness on pressure, 220

- Appendix, abscess of, localised, 221 diagnosis from ileo caecal tuberculosis, 265 cancer of, 221 diverticula of, 222 normal, radiological appearances of, 213, 215 filling and emptying of, 214 radiology of, technique of, 213 Arterio mesenteric occlusion, chronic, causing duodenal ileus, 143 Ascaris lumbricoides in ileum, radiological demonstration of, 107

B

- Barium air double contrast enema in examination of colon, 228 biscuit, 10 cream followed by water in diagnosis of oesophageal foreign bodies, 21 use of, 10 use of, in diagnosis of oesophageal foreign bodies, 21 emulsion, dehydrated, 34 in duodenal examination, 116 preparation of, 35 enema appearances in carcinoma of colon, 279 in chronic obstruction of colon, 287 in diverticulitis of colon, 287 in gastric fistula, 85 in irritable colon, 255 in mucous colitis, 256 formulae of, 35 in examination of colon, 223 apparatus and administration, 225 opaque medium, 224 preparation of, 224 of pancreas, 332 meal, appearances in gastric fistula, 65 examination, double meal technique, 37 of chronic intestinal obstruction, precautions in use of, 205 of chronic obstruction of colon, 270 of colon, 223 of diverticulitis of colon, 287 of mucous colitis, 216 of pancreas, 331 of peptic ulcer, 57 preliminary preparation, aperients, 37 drugs, food, 3 technique of time intervals formula of, 35 pellet, 10 wool, 10

- Barium wool, use of, in diagnosis of oesophageal foreign bodies, 21
- Berg's explorator, use of, 42
- pressure cone, use of, in radiological examination following stomach operation, 152
- Bile, peritonitis, in stomach, 107
- Bile ducts, malformations of, congenital, 320
tumours of, 341
- Biliary tract, anatomy and physiology of, 305
dyskinesia of, 336
extrahepatic, anatomy of, 305
malformations of, congenital, 320
pathology of, 320
radiological examination of preliminary preparation, 314
technique of, 314
visualisation of post-operative 311
- Billroth I operation, radiological appearance after, 156
- Billroth II operation, complications of, 152
radiological appearances after, 151
- Borborygmi, 113
- C**
- Cæcum, anatomy of, 236
carcinoma of, diagnosis from tuberculosis, 265
filling of, 237
hastral churning in, 239
radiological appearances of, in ulceroprolapse, 247
stasis of, 267
undescended causes of, 214
- Calculus, appendix, 217
gall bladder, 323
intraluminal, diagnosis from gall-stones, 325
kidney, diagnosis from gall stones, 326
pancreatic, 353
diagnosis from gall stones, 324
salivary, 2
differential diagnosis of, 5
radiography of, 4
- Cancer *See under names of organs and regions*
- Cardia, achalasia of, 24
- Cardiospasm, aetiology and pathology of, 23
radiological appearances of, 23
treatment of, radiographic control of, 29
- Cartilages, costal calcified, diagnosis from gall stones, 327
- Cephalometry, disproportion in, 404
McDonogh's method, 403
preparation of standard scales, 404
Reece's method, 402
Rowden's method, 402
Thoms' method, 401
Walton's method, 402
- Chauli compression band, use of, 42
in radiological examination, following gastic operations, 152
- Chassard and Lapine's method of pelvimetry, 399
- Cholecystectomy, peritoneal, following, 137
- Cholecystitis, acute, radiological appearances of, 322
- chronic, mild, radiological appearances of, 323
intensity of shadow, 324
rate of emptying of gall bladder, 324
rate of filling of gall bladder, 323
radiological appearances of, 322
- oblitans, 322
- Cholecysto-duodenal fistula, 137
- Cholecysto-duodenostomy, radiological appearances after, 155
- Cholecysto-gastric fistula, 87
- Cholecysto-gastrostomy, radiological appearances after, 153
- Cholangiography, 315
findings in effect of extrabiliary disease on, 313
in acute liver necrosis, contraindicated, 342
in study of bile concentration, 312
intravenous, contraindications, 316
technique of, 316
- oral, intensive, technique of, 319
single dose, technique of, 318
rapid, technique of, 317
- Cholecystostomy, gall bladder after, 313
- Cholesterosis, 323
- Celiac disease, radiological appearances in adults, 251
in infants, 250
- Colitis due to specific infections, 261
mucous, radiological appearances of, 256
simple, 255
syphilitic, 262
ulcerative, aetiology of, 236
pathology of, 237
radiological appearances developed stage, 260
hyperplastic and sclerotic stage, 261
stage of onset, 260
- Colon, absence of, 202
actinomycetous of, 268
adenocarcinoma of, 278
- adenoma of multiple, 277
adhesions of radiological appearances of, 252
after inflation with gas, radiological appearances of, 234
anatomical variations of, 241
- anatomy of, 236
- anomalies of, due to adhesions and herniae, 252
fixation, 246
length, 241
rotation, 243
shape, 244
size, 243
- antiperistalsis of, 239
- ascending anatomy of, 236
- carcinoma of cerebriform, 281, 282
- enteropexy in, 284
- fixation of growth, 284
- morph anatomy and site of, 278
- radiological appearances of, 278

- Colon, carcinoma of, radiological appearances of, filling defect, differential diagnosis of, 282 varieties of, 278 obstructive signs, 283 serratus, 278 descending and iliac portions, anatomy of, 236 dilatation of, congenital, aetiology and morbid anatomy of, 248 clinical features of, 248 radiological appearances of, 248 after sympathectomy, 249 displacement of, subphrenic, 241 diverticula of, inflammatory changes in, 286 pathology of, 285 perforation of, 293 site of, 286 diverticulitis of, aetiology of, 285 clinical features of, 285 complications of, 297 definition and terminology of, 285 radiological appearances of, after barium meal, 293 after thorium three stage enema, 294 pre diverticular stage, 288 stage of diverticulitis, 290 stage of diverticulosis, 289 technique, 287 treatment of, radiological control of, 295 diverticulosis of, 285 double barrelled, 292 examination of barium air double contrast enema 228 barium enema, 223 barium meal, 223 plain radiogram 223 thorium air double contrast enema, 229 filled, radiological appearances of, 232 fixation of, by adhesions, 232 function of, 237 antiperistalsis 239 filling, 237 mass movement 238 pendulum movement of Rieder, 239 gaseous distension of, causing gastric dis placement, 110 hanstral churning of 239 herniation of, 234 inflammatory diseases of, 234 insufflation of, in thorium air double contrast examination, 231 irritable, radiological appearances of, 235 long, 241 micro, 232 mucosal pattern of, pathological variations in, 233 muscular coat of, 237 obstruction of, 267, 269 acute, 269 chronic, 269 pelvic, anatomy of, 236 peritoneal adhesions involving, 232 plication of, types and forms of, 232
- Colon, polyps of, 277 radiological appearances of, in ulceroprolapse, 247 rate of transit through, 239 sarcoma of, 284 short, 241 sigmoid volvulus of, 274 splenic flexure, anatomy of, 236 stasis of, 267 transverse, anatomy of, 230 tumours of, benign, 277 malignant, 278 ulcer of, carcinomatous perforation of, 284 upper, filling of, 237 Colospasm, radiological appearances of, 235 Compression in diagnosis of duodenal ulcer, 126 Constipation, 267 colic, 267 radiological appearances of, 268 rectal radiological appearances of, 268 Crane's string sign, 238, 236 Crohn's disease clinical features of, 210 differential diagnosis of, 212 radiological appearances of, 211 Cystography in diagnosis of placenta previa, 443 Cysts of liver hydatid, 349 calcified diagnosis from gall stone, 327 of ovary, 363 demonstration of 379 of pancreas, 354 of spleen hydatid 351 of stomach 86
- D
- Deglutition, process of, 10 Diaphragm, anatomy of 179 contour of, irregularities of, 180 elevation of unilateral congenital, 190 evagination of, 190 aetiology of, 190 differential diagnosis of, 192 pathology of, 191 radiological appearances of, cardiac displacement, 192 content of dome, 191 diaphragmatic outline, 191 gastric contents, 192 gastric deformity, 192 lung tissue visible through dome, 191 movements of dome, 191 Hernia of, 180 See also Hernia, dia phragmatic inferior relationship, 179 movements of, 180 normal, radiological appearances, 179 upward displacement of one lobe of, causes of, 180 Diverticula, gastric, 103 pharyngeal, 15 Diverticulitis of colon, 285 See also Colon, diverticulitis Diverticulosis, duodenal, 138

- Duodenal and gastric ulcer incidence of 57
tube *in situ*, radiological appearance of, 107
- Duodenitis, 133
radiological appearances of between bulb and ampulla, 136
in bulb, 131
- Duodeno jejunal flexure, normal, radiological appearance of 123
- Duodeno jejunostomy, radiological appearance after, 134
- Duodenum abnormalities of congenital 147
adenoma of, 149
after operation, radiological examination technique of, 151
anatomical relations of 114
anatomy of 114
bulb of radiological appearance of 116
in ulcer, 125, 127
variations in due to degree of filling, 118
due to habitus of patient, 118
due to posture of patient, 119
- carcinoma of pathology of 150
radiological appearances of 150
- diverticula of ampillary, 142
radiological appearance of 142
classification and incidence of, 138
primary, characteristics of 138
differential diagnosis of 140
pathology of 139
sequela of 137
- radiological appearances of 139
- secondary, pulsion type 141
radiological appearances of, 141
symptomatology of 142
traction type 141
symptoms of 139
- fibroma of 149
- fistula of external 137
internal 137
- in enlargements of head of pancreas 150
- intussusception of 149
- intervenous fixed 149
mobile 149
- lipoma of, 149
- looped, 141, 148
- invagination of, 149
- normal, 114
radiological appearance of ampulla of Vater 123
duodeno jejunal flexure 123
first portion, duodenal bulb 116
portion distal to bulb 120
- radiological appearance of *in vivo* 247
- radiological examination of technique of 115
opaque medium 116
place in 115
posture in 115
pressure in 115
- in situ* invagination partialis: common mesenterum, 149
structure of, 115
- Duodenum, tumours of, benign, 149
ulcer of, clinical features of, 124
coast branchiiformis, 129
following gastro jejunostomy, 162
gastric stasis following, 131
perforation of, 124
"persistent fleck" sign in, 124
pneumatic deformity, 129
radiological appearance of, accessory pocket, 132
adjacent changes in bulb, 127
Åkerblom deformity, 131
deformity from penetrating ulcer, 132
deformity of bulb associated with dis-tortion of pyloric canal 131
general bulb deformity, 129
healing stage, 134
mesentra deformity, 131
mecho deformity, 131
retraction (Åkerblom), 131
secondary disturbances of stomach in, 132
small stenosed bulb 132
visualised ulcer crater, 124
- shamrock deformity, 129
- sitae of, 124
- Dyschezia, 268
- Dyskinésia, biliary, 336
- Dysphagia, 14
pharyngeal, 13
- E**
- Enteroptosis, 240
- Enterospasm in carcinoma of colon, 284
- Figlottis, rôle of, in deglutition, 11
- Fistule en coupe à champagne, 48
- Friututerine tumours, demonstration of, 378
- F**
- Fallopian tubes, injection of opaque fluid into, 370
patency of, investigation of, 364
transuterine inflation of, contraindications, 366
technique of, 366
- Finney's pyloroplasty, radiological appearance after, 170
- Fistula, cholecysto-colon, 318
cholecysto-duodenal, 137
cholecysto-gastric, 81
duodenal, 137
gastric, 84
radiological appearances of, 84, 85
- gastro-chole, 84
following gastro jejunostomy, 84, 165
- ileal, 293
- jejunal, 293
- salivary, 6
- Fistula *in situ*, 299
- Flocculation in examination of colon, 229

INDEX

Fluoroscopy of appendix, 214
of diaphragmatic hernia, 187
of duodenum, 113
of oesophagus in cardiospasm, 29
of small intestine, 197
of stomach, 39
use of, in treatment of oesophageal stricture by bougies, 27

Fœtus, anomalies and abnormalities of, 419
anencephaly, 420
hydrocephalus, 410
microencephaly, 421
meningocele, 430
rudimentary limbs, 430
spina bifida, 420
thyroid tumour, 428

danger to, from deep X-ray therapy, 444
immobilisation of in obstetric radiology, 385
intrauterine death of, radiological demonstration of, 431

maturity of, radiological estimation of, 406
factors in, 407
from ossific centres, 410
limitation of cephalometric methods
410
medico legal aspects of, 411
Reece's method, 408
Roberts method, 407

occipito frontal diameter of, in relation to maturity, 408

position and presentation of, radiological appearances of, 412

post maturity of 410

Foreign bodies in alimentary canal, 106
in oesophagus opaque, 19
transparent, 20

Fraenkel's peristaltic jump sign in cancer of stomach 90
sign in gastric ulcer, 71

G

Gage Courtney method of pelvimetry, 398

Gall bladder adenoma of, 340
adhesions of, 338
anatomy of 303
carcinoma of primary 341
distension of, radiological appearance of 336
double, 320
emptying of, mechanism of, 312
radiological appearances of, phase of contraction, 313
preparatory phase, 313
resting phase, 313

function of, 311

long or hyposthenic, radiological appearances of, 311

malformations of, congenital, 320

non-calcified, visibility of, without cholecystography, 334

normal parts of, 305
types of, 305

Gall bladder, ovoid or sthenic, radiological appearances of, in erect position, 307
in prone position, 306
in supine position, 307

papilloma of, 340

porcelain, 331

radiological appearances of, after cholecystectomy, 343

spheroidal or hypersthenic, radiological appearance of, 308

strawberry, 323

tumours of, radiological appearances of, 340

walls of, calcification of, 331

Gall stones, 325
cholecystography and, 328
composition of, 325
differential diagnosis of, 326
impaction of, in intestine, 276

Gas bubble sign in cancer of gastric fundus, 97

Gastrectomy, complete, Moynihan, radiological appearances after, early and late, 177, 178
partial, Billroth II, complications of, 172
radiological appearances after, 171

Polya, 172

Polya Balfour, 173

Polya Funsterer, 176

Polya Lake, 178

Polya Moynihan, 172
complications of, 174
radiological appearances after, 173

Gastric adhesions, 77
and duodenal ulcer, incidence of, 57
contents in radiological examination of evagination of diaphragm, 102
evacuation, rate of, factors governing peristalsis, 56
pyloric function, 56
tonus of stomach, 56
type of meal, 55

Mucosa, changes in, due to distension with barium emulsion, 54
due to extraneous factors, 54
due to extrinsic pressure, 57
due to inflammation, 57
due to neoplasms, 55
due to presence of food, 54
due to ulcer, 57
pathological, 64
physiological, 54
normal, 52
form and functions of, 52

Ruge in gastritis, 80
increased thickness of, in duodenal ulcer, 132
normal, 52

Stasis following duodenal ulcer, 133

Ulcer, acute, pathology of, 58

carcinomatous 98

chronic, active radiological appearances in barium filled stomach, 60-64
healing, radiological appearances in barium filled stomach, 64

pathology of, 58

Gastric ulcer, chronic, site of, 58
 size and form of, 58
 following gastrojejunostomy, 162
 localized tenderness on pressure 70
 malignant and simple, radiological differential diagnosis of, 100
 pathology of, 58
 radiological appearances of, circumferential signs, hour glass contracture of stomach, 75
 pyloric stenosis 71
 crater in mucosal pattern roentgenogram 59
 direct sign 59
 in barium filled stomach, 60
 indirect signs, Fränkel's peristaltic jump, 71
 gastric evacuation, 70
 gasterospasm 66
 peristalsis 70
 segmental rigidity and straightness of lesser curve, 71
 size and tone of stomach, 67
 simple and malignant radiological differential diagnosis of, 100
 in aetiology of cancer 88
 simplex, 69
 subacute pathology of, 58
 with normal pyloric function 69
 with pyloric stenosis 69-70
 with pyloric obstruction 69-70
 with pylorospasm 69-70

Gastritis 80
 atrophic 81
 following gastrojejunostomy 161
 perianastomotic 81

Gastro-ileal fistula 84

Gastro-gastrostomy, radiological appearances after 154

Gastro-ileal reflex 200

Gastro-jejunal ulcer following gastro-jejuno-ostomy 164

Gastro-jejuno-ileal fistula 84

Gastrojejunostomy, anterior, radiological appearances after 170
 complications of duodenitis 146
 posterior complications of contracture of pylorus antrum 167
 duodenum 161
 gastritis 161
 jejunal thumbing 161
 jejunitis 161
 malposition of stoma 164
 narrowing of stoma 163
 peptic ulcer 162
 radiological appearances of 160-163
 retrograde jejuno-gastric intussusception, 163
 radiological appearances after pressure control of efferent loop in, 179
 radiological appearances after 157

Gastroparesis in brest sign of gastric ulcer, 66
 intrinsic or extrinsic, 68

Gastritis, 250

Genital tract, female, radiography of, 363
 Glands calcified, in abdomen, diagnosis from gall stones, 327
 Glenard's disease, 246
 Gynaecology radiology in 363

II

Hanckel, niche of 59
 Heart displacement of in evagination of diaphragm 192

Hepato-diaphragmatic interposition of colon, 241

Hepato-angioplasty 347

Hernia, diaphragmatic acquired 181
 non traumatic 184
 radiological appearances of 184
 traumatic 185
 radiological appearances of, 189
 anatomical features of 181
 classification of 181
 congenital, 181
 para-oesophageal, 183
 radiological appearances of 186
 through the dia- 187
 radiological appearances of 186
 through the foramen of Morgagni 184
 through the pleuro-peritoneal hiatus 181
 embryology of 180
 radiological examination technique of 183
 of small intestine 207

Hirschsprung's disease 250

Hirschsprung's disease 248

Hinton's method of pneumoperitoneum, 798

Horch's shadow food, use of, in alimentary tract examination 33

Houston, valves of 297

Hydrocephalus of fetus, radiological demonstration of, 419

Hydrocephalus indications of 376

Hypertension in duodenal ulcer 132
 of stomach 46

Hypertonus in duodenal ulcer 132
 of stomach 46

Hypopharyngeal carcinoma 17

I

Intestine, chronic 204
 plastic clinical features of 210
 differential diagnosis of 212
 radiological appearances of 211
 regional 210
 tuberculous hypertrophic 210
 in erative 207

Ileocecal tuberculosis, clinical features of, 263
 differential diagnosis of 265
 pathology of 263
 radiological appearances of 263
 valve 201

Ileogastric reflex 200-221

Ileum, anatomy of, 197
 carcinoma of, 204

- Ileum, fistula of,** 203
gall stone impaction in, 276
movements of, radiological appearances of, 189
terminal radiological appearances of 200
Ileus duodenal chronic, 143
 in children, 147
 non obstructive, 143
obstructive, due to adhesions and bands, 146
 due to arterio mesenteric occlusion,
 radiological appearances of, 145
 symptomatology of, 144
 due to extrinsic pressure, 143
 tumour, 146
 due to gastro jejunostomy, 146
 due to intrinsic lesions, 143
 due to periduodenitis, 146
Incisura, posterior (pancreatic), of Twinning,
 39, 50, 352
Imencephaly of fetus, radiological demonstra-
 tion of, 421
Intestine, large, anatomy of, 236
 function of, 237
 rate of transit through, 230
 small anatomy of, 197
 carcinoma of, 208
 diseases of, 202
 diverticula of, acquired, 202
 fistulas of, 203
 hernia of, 207
 Meckel's diverticulum of, 202
 movements of, radiological appearances of
 198
 obstruction of, acute 204
 chronic, 205
 radiological appearances of, in erect
 position, 200
 in supine or prone position, 206
 radiological appearances of, in viscera
 htosis, 247
 radiological examination of, technique of,
 197
 rate of transit through, 200
 sarcoma of, 209
 tuberculosis of, 203
 tumours of innocent, 208
 malignant, 209
Intussusception, 271
 classification of, 272
jejunum-gastro, retrograde, following gastro
jejunostomy, 169
 pathological anatomy of, 272
 radiological appearances of, 273
- J**
- Jejunal dumping following gastro jejunostomy,** 161
 ulcer following gastro jejunostomy, 164
Jejunitis following gastro jejunostomy, 161
Jejunum, anatomy of, 197
 fistula of, 203
 movements of, radiological appearances of,
 198

- K**
- Kidneys, enlargement of, causing gastric dis-**
 placement, 108
Krukenboeck's sign, 191
Kocher's operation, radiological appearances
 after, 156
- L**
- Laryngeal orifice, closure of, in deglutition,** 11
Larynx, rôle of, in deglutition, 10
Limbs, rudimentary, of fetus, radiological
 demonstration of, 430
Linitis plastica, carcinomatous, 92
Lipiodol use of, in sialography, 3
Liver, abscess of, radiological appearances of,
 349
 anatomical features of, 347
 calcification of, radiological appearances of,
 349
 cysts of, hydatid radiological appearances of,
 349
 diseases of, 341
 enlargement of causing gastric displace-
 ment, 108
 eversion of diaphragm in, 194
 general causes of, 347
 radiological appearances of, 347
 metastases of, demonstration by thorotrust,
 348, 349
 necrosis of, acute cholecystography contra-
 indicated 342
 radiological appearances of, after thorotrust
 administration, 348
 in visceroptosis, 247
 examination of, hepato hennography, 347
 tumours of, elevation of diaphragm in, 184
- M**
- McDonogh's method of cephalometry,** 403
- Magenstrasse,** 92
- Meal, type of, effect on gastric evacuation,** 55
- Meckel's diverticulum, varieties of,** 202
- Megabulbus,** 147
- Megacolon,** 248
- Megaduodenum,** 143
- Meningocele in fetus, radiological demonstra-**
 tion of, 430
- Meniscus effect in carcinomatous ulcer,** 98
- Meryanism,** 113
- Microbulbus,** 147
- Micro-colon,** 242
- Mikulicz's disease, sialographic appearances,** 7
- Movnnhan's complete gastrectomy, radiological**
 appearances after, early and late, 177,
 178
- Muscular hypertonus, localised, causing eas-**
 eade stomach, 48
- N**
- Naso pharynx, closure of, in deglutition,** 11
Nerve phrenic, paralysis of, 102

O

Obstetrics. radiography in, apparatus and accessories, 383
current, 383
danger to mother or fetus, 444
exposure, 384
focus film distance, 383
general technique, 383
immobilisation of the fetus, 387
information available from, 385
kVovoltage, 383
position of patient, 384
suppression of maternal respiratory movement, 385
technique of, 383
Oesophagitis, 28
Oesophagus, anatomy of, 8
sites of, 21
carcinoma of, morbid anatomy of, 21
perforation of, 21
radiological appearances of, 22
after intubation of radium therapy, 24
sites of, 21
types of, 21
dilatation of, due to gastric lesions, 32
diseases of, 14
fibroma of pedunculated, 25
foreign bodies in, 10
malformations of, congenital, 18
normal, radiological appearances of, 12
obstruction of, due to extrinsic pressure,
causes of, 31
site of, in relation to radiography, 14
spastic, 28
stages of, 14
radiography of, double swallow method, 9
opaque media for, formula of, 9, 10
technique of, 9
role of, in deglutition, 11
spasm of from ulceration, 31
hiopathic, 31
stricture of, benign, aetiology and morbid
anatomy of, 26
types of, annular, 26
radiological appearances of, 26
tubular 26
radiological appearances of, 26
tumours of, malignant, 21
simple, 25
varix of, 33
Opaque meal in examination of diaphragmatic
hernia, 180
Orthotony of stomach, 46
Ovary, cysts of, 363
causing gastric displacement, 108
demonstration of, 370
dermoids of, 363

P

Pancreas anatomy of, 351
calculi of, radiological appearances of, 355
carcinoma of, 355

Pancreas, cysts of, true and false, 351
radiological appearances of, 354
head of, enlargements of, duodenum in, 150
radiological examination of, barium enema,
352
barium meal, 351
fluoroscopy of diaphragm and lung
bases in, 352
lateral, with air inflation of stomach, 352
plain postero anterior film, 351
tumours of, air insufflation of stomach in
diagnosis of, 43
causing gastric displacement, 108
Pancreatitis, chronic, 353
hemorrhagic, acute, 353
Parotid gland, anatomy of, 1
calculus of, 4
Pelvis organs, female, radiography of com
bination of peritoneal inflation and
peritoneal injection, 379
injection of contrast media, 364
injection of opaque fluid, 370
peritoneal gas inflation through
abdominal wall, 367
simple or direct, 363
transuterine inflation, 366
uterosalpingography, 370
Pelvometry, radiological, 392
correction tables, 390
estimation of measurement of conjugate
from lateral view, 395
of the inlet, Courine Gage's method,
technique of, 395
Hooton's method, technique of, 395
Roberts' method, technique of, 391
Rowden's method, technique of, 397
Thoms' method, technique of, 392
of the outlet, antero posterior diameter 400
Chassard and Lapin's method tech
nique of, 399
Roberts' method, technique of 400
transverse diameter, 399
Pelvis, abnormalities of, acquired, 390
congenital, 390
deformities of, maternal, 390
joints of, changes in, during pregnancy, 398
Peptic ulcer following Polvo Moynihan partial
gastrectomy, 174
sites of, 57 *See also Gastric ulcer*
Peritoneostitis, 334
Periappendicitis after cholecystectomy, 137
bulbar, 135
causing ileus, 146
of third and fourth portions, 137
Peritoneal inflation in suprarenal disorders, 356
Peristalsis of stomach, 46
Peristaltic jump, Frenkel's, in cancer of
stomach, 90
Peritoneal cavity free gas in, causes of, 194
radiological demonstration of, 195
gas inflation of, through the abdominal
wall, 367
diagnostic applications of, 369
technique of, 367

Peritoneal cavity, injection of gas into, 364
 transuterine inflation of, 365
 "Persistent fleck" sign of duodenal ulcer, 124
 Petit's eversion, 190
 Pharyngeal space, rôle of, in deglutition, 10
 Pharynx, anatomy of, 8
 cancer of, 17
 diseases of, 14
 diverticula of, congenital post tonsillar, 15
 deep pressure 15
 radiological appearances of, 15
 traction, 17
 pressure of, extrinsic 15
 radiography of, indications for, 8
 Phrygian cap deformity of gall bladder, 320
 Placenta praevia, 436
 diagnosis of by cystoscopy, 443
 Plastic limits, aetiology and pathology of, 82
 radiological appearances of, 82
 Pliae, of colon, pathological variations in, 233
 types and forms of, 232
 Plummer Vinson syndrome, 18
 Pneumoperitoneum, transabdominal in diagnosis of pregnancy, 387
 Polva, anterior left right operation 172
 modified operation, with entero anastomosis in Y, 173
 radiological appearances after, 175
 partial gastrectomy, 172
 Polya Balfour partial gastrectomy, 173
 radiological appearances after 175
 Polya Finsterer partial gastrectomy, radiological appearances after 176
 Polya Lake partial gastrectomy, radiological appearances after, 175
 Polya Moynihan partial gastrectomy, 172
 complications of, 174
 radiological appearances after, 173
 Polyposis gastrica 88
 Post cricoid carcinoma 17
 Post maturity, radiological estimation of 410
 Pregnancy, changes in the pelvic joints in, 388
 diagnosis of, by amniography, 416
 by direct radiograph, 386
 by use of contrast media, 386
 ectopic, diagnosis of uterosalpingograph in, 377
 radiological demonstration of, 419
 multiple, 414
 position and presentation of fetus 412
 Pressure, use of, in duodenal examination 116
 Pyloroplasty, Finney's, radiological appearances after, 170
 simple, radiological appearances after, 155
 Pylorospasm, diagnosis from post ulcerative pyloric stenosis, 74
 effect on gastric evacuation, 56
 with gastric ulcer, 69, 70
 Pylorus achalasia of, effect on gastric evacuation, 56
 with gastric ulcer, 69, 70

Pylorus, antrum of, contracture of, following gastrojejunostomy, 167
 function of effect on gastric evacuation, 56
 gaping, of cancer, 90
 obstruction of, organic, effect on gastric evacuation, 56
 with gastric ulcer, 69, 70
 stenosis of, from tumours, diagnosis from post ulcerative stenosis, 75
 hypertrophic, chronic, in adults, differential diagnosis of 103
 morbid anatomy of, 103
 radiological appearances of, 103
 congenital, aetiology of, 102
 radiological appearances of, 102
 technique in, 102
 in adults diagnosis from post ulcerative stenosis, 75
 post ulcerative, differential diagnosis of, 74
 stages of, 71-74
 ulcer of, following gastrojejunostomy, 164
 radiological appearances of, direct signs, 63
 undue patency of, effect on gastric evacuation, 56

R

Rectum, anatomy of, 297
 carcinoma of, 297
 malformations of, congenital, 300
 stricture of, simple, congenital, 298
 post inflammatory fibrous, 299
 spasmode, 299
 traumatic, 298
 Reece's method of cephalometry, 402
 of estimating fetal maturity, 408
 Reflex gastro ileal 200
 Reflex ileo gastric, 200, 221
 Relaxatio or evantratio diaphragmatica, 190
 Rieder, pendulum movement of, 239
 Rivinus, ducts of, 1
 Roberts' method of estimating fetal maturity, 409
 of pelvimetry, 393, 400
 Rowden's method of cephalometry, 402
 of pelvimetry, 397
 Rumination, 113

S

Sacro iliac joint, changes in, in pregnancy, 388
 Salivary glands, anatomy of, 1
 fistula of, 6
 radiology of, 2
 tumours of, 7
 Schoemaker's operation, radiological appearances after, 156
 Scoliosis causing gastric displacement, 108
 Screen examination of duodenum, 115
 Sialectasis, 7
 Sulcus, chronic, 6
 Sialogram, parotid, normal 3
 Sialography, indications for

- Radiography, preparation of patient for, 3
 technique of, 2
Situs inversus partialis communis mesenterium., 243
Socia parotidae., 1, 5
 Spalding's sign of intrauterine death, 431
 Spasm, localised, causing cascade stomach, 48
 Spina bifida in fetus, radiological demonstration of, 429
 Splanchnopleurosis, 246
 Spleen, anatomy of, 350
 calcification of, 350
 cysts of, hydatid, 331
 enlargement of, causing gastric displacement, 108
 eventration of diaphragm in, 194
 infarct of, 350
 phleboliths of, 341
 ptosis of, 350
 radiological appearances of, 350
 in visceropexy, 247
 tuberculous foci, calcification of, 350
 Spleen flexure, distension of, with gas causing cascade stomach, 48
 Steatorrhena, idiopathic, 230
 Stensen's duct, 1
 Stereoscopy of salivary glands, 3
 Sternberg's sign in ileo-cecal tuberculosis, 263
 Stomach, acromegalic of, 84
 adenoma of, 86
 adhesions of, 77
 after operation, radiological examination, technique of, 131
 air insufflation of, 43
 anatomical relations of, 33
 anatomy of, 33
 angioma of, 86
 bed, 39
 ballooning of, 75
 spastic, pure, 67
 cancer of, 85
 aetiology of, 84
 age and sex incidence of, 85
 encephaloid, 93
 air insufflation in, 43
 finger print defects in, 94
 funiculus, 93
 sites of anterior or posterior wall, 97
 fundus, 97
 pyloric stricture, 98
 hour glass contracture in, 91
 medullary, 93
 pathology of, 85
 radiological classification of, 69
 recurrent, after Polya-Mornihan partial gastrectomy, 175
 stricture, diagnosis from pylone stenosis, 103
 diffuse, radiological appearances of, 92
 in pyloric region, 92
 localised, radiological appearances of, 89
 site of, 88
 with peptic ulcer, radiological appearances of, 93
 Stomach, cardia of, ulcer of, radiological appearances, direct sign, 66
 cascade, causes of, 48
 physiological, 75
 cauterisation of, radiological appearances after, 154
 cirrhosis of, 82
 crop and spill, 48
 crevices of, 68
 deformities of, pressure, from colon, 110
 from left kidney, 108
 from liver, 108
 from neighbouring organs, 107
 from ovarian cyst, 108
 from pancreas, 108
 from pregnant uterus, 108
 from scoliosis, 108
 from spleen, 108
 Displacement of, in eventration of diaphragm, 192
 by pressure, causes of, 107
 Diverticula of, acquired, 105
 congenital, 107
 Erosions of, haemorrhagic, 59
 evacuation of, rate of, factors governing, 53
 examination of, compression in, 41
 technique of, 39
 fibromyoma of, 86
 fibroma of, 86
 fibromatosis of, 82
 fistula of, external, 84
 internal, 84
 foreign bodies in, 107
 form of, 39
 fundus of, cancer of, signs of, 97
 ulcer of, radiological appearance of, direct signs, 65
 hair ball in, radiological appearances of, 107
 hour glass contracture of, cicatrical, simple, 76
 due to extrinsic pressure, 75
 malignant, 91
 organic, 77
 physiological, 48, 75
 with organic stenosis, 76
 without organic stenosis, 75
 Hyperperistalsis of, 47
 Inflammation of, 80. See also Gastritis
 leather bottle, 82
 in cancer, 92
 Lesions of, causing oesophageal dilatation, 32
 Lipoma of, 86
 Lymphoma of, malignant, 101
 Lympho-angiomata of, 101
 Malacoma of, 52. See also Gastric mucosa
 mucosal relief pattern of, technique of, demonstration of, 42
 Myoma of, 86
 Neoplasms of, 86. See also Stomach, tumours of
 normal, anatomy of, 33
 Antral sphincter of, 47
 cardiac orifice of, 44
 greater curve of, 44

Stomach, normal, lesser curve of, 44
lower pole of, 44
mucosa of, 52
peristalsis of, 46
pylorus, 45
radiological appearances of, in erect lateral view, 51
in erect position, 43
in prone position, 51
in supine position, 49
tonus of, 45
operations on, abolishing sphincteric control, 152, 157
radiological examination following, 152, 157
leaving partial sphincteric control, 151
radiological examination following, 152, 155
leaving sphincteric control, 151, 154
radiological examination following, 152, 154
peristalsis of, effect on evacuation, 56
peristomach bezoar in, 107
polyposis of, 86
air insufflation in, 43
radiological appearances of, 86
radiological appearances of, in viscerotaxis, 237
sarcoma of, clinical features and site of, 100
radiological appearances of, 101
round-celled, 100
spindle-celled, 100
simple excision of ulcer of, radiological appearance after, 143
sleeve resection of, radiological appearances after, 154
state of following duodenal ulcer, 135
syphilis of, pathology and radiological appearances of, 83
thoracic, 33
complete, 183
tonus of, effect on evacuation, 56
tuberculosis of, hypertrophic, 83
ulcerative, 84
tumours of, benign, 86
connective tissue, 86
cystic, 86
glandular, 86
radiological appearances of, 86
ulcer of, 57
air insufflation contraindicated in, 43
radiological appearances of, circumscribed signs, gastric adhesions, 77
contracture of gastro hepatic omentum, 77
See also Gastric ulcer
volvulus of, acute, 111
on cardio pyloric axis, 111
on transverse axis, 111
wedge resection of lesser curve, radiological appearances after, 154
Strawberry gall bladder, 323
Stoma, malposition of, following gastro jejunostomy, 168

Stoma, narrowing of, following gastro jejunostomy, 165
Sublingual gland, anatomy of, 1
calculus of, 4
Submaxillary gland, anatomy of, 1
calculus of, 4
Suprarenal glands, anatomy of, 356
calcification of, diagnosis from gall stone, 328
tumours of, 356
Swallowing, physiology of, 10
Sympathectomy for Hirschsprung's disease, radiological appearances after, 249
Symphysis pubis, changes in, in pregnancy, 398
Syphilis of stomach, pathology and radiological appearances of, 83

T

Thoms' method of cephalometry, 401
of pelvimetry, 392
Thorium air double contrast enema in carcinoma of colon, 241
in examination of colon, 219
failures in technique of flocculation, 231
insufflation of colon, 231
preliminary preparation for, 230
radiological appearances in first stage, 232
in third stage, 234
of pathological variations in mucosal pattern 213
of plumb in second stage, 231
technique of injection, 230
in irritable colon, 235
in mucous colitis, 236
Thorotrast, effect of, on reticuloendothelial system, 349
properties of, 348
use of, in hepato lienography, 348
, administration of, 348
Thyroid, tumour of, in fetus radiological demonstration of, 428
Tongue, rôle of, in deglutition, 11
Transuterine inflation, technique of, 366
Inchobezoar, radiological appearances of, 107
Triplets, radiological demonstration of, 417
Trusst compressor for use in radiological examination, following gastro operation, 152, 153
Tuberculosis, ileocecal, 262
of stomach, 83
Twining, posterior (pancreatic) invagination of, 39, 50, 352
Twins, radiological demonstration of, 417

U

Ulcer, duodenal and gastric, incidence of, 57
peptic, air insufflation of stomach contra indicated, 43
sites of, 50 *See also Gastric ulcer*
simplex, 69

Umbrose, use of, in alimentary tract examination, 35
 Uterosalpingography, contraindications, 370
 diagnostic applications of, 373
 technique of, 370
Uterus, anteflexion of, demonstration of, 376
 bicornuate, demonstration of, by utero-salpingography, 376
 carcinoma of, demonstration of, 378
 fibroids of, and early pregnancy, diagnosis between, 376
 calcified, 383
 demonstration of, 376, 379
 fibromyoma of, 383
 pregnant, causing gastric displacement, 109
 radiography of, direct, 383
 retroflexion of, demonstration of, 376

V

Varix, oesophageal, 33
Vater, ampulla of, dilatation of, 142

Vater, ampulla of, normal radiological appearance of, 123
 Viscera, abdominal, transposition of, 244
Visceroptosis, 216
 due to relaxation of abdominal wall, 246
 in normal individuals of hypotonic habitus, 246
 radiological appearances of, 247
Volvulus of intestine, 274
Volvulus, act of, radiological appearance of, 56

W

Walton's method of cephalometry, 402
Wharton's duct, 1

X

X ray therapy, deep, danger to foetus, 444